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FURTHER YIELDS FROM THE CALABAR PLANTATION OIL PALMS.

By E. H. G. SMITH, M.A.

In the second part of a first paper (1), the yields for the period 1922-28 from four plots of the Calabar plantation palms were analysed. In the present paper the yields of a fifth plot are published for the first time, and the analysis of the yields of the other four plots is completed to the end of 1930. The six types of the Oil Palm growing at Calabar are described in the first paper. It is perhaps more convenient to classify these palms into three main types each with two sub-types, one a thick-shell, and one a thin-shell, form. The different types are distinguished upon fruit form alone. Apart from this variable character all the palms appear to be identical. The types are as follows:—

Main Types	*Sub-types or Forms.* *
(I) Ordinary type.	(*a*) Ordinary thick-shell (Okporo).
	(*b*) Ordinary thin-shell (Osok).
(II) Green-fruited type.	(*a*) Green-fruited thick-shell (Afia Oku).
	(*b*) Green-fruited thin-shell (Afia Oku).
(III) Mantled type.	(*a*) Mantled thick-shell (Ayara Mbana).
	(*b*) Mantled thin-shell (Ayara Mbana).

The ordinary thick-shell is the dominant form both generally, in the bush, and in the Calabar plots. Data for the other types is available only from a comparatively small numbers of trees.

Plot Yields.

The plot yields are now considered. All types of fruit occurring in each plot are treated separately and the yields of young palms are ignored. The method adopted in compiling the tables was fully described in the first paper. Briefly it is as follows:—

* *Note.*—The Efik native names are given in brackets.

Two tables, termed tables A and B, are given for each plot. In table A yields per plot and per tree are recorded. Table B gives annual yields per acre and includes the weight of mesocarp oil (obtainable by the cooker-press process), and the weight of kernels. In calculating yields per acre for table B the actual acreage of each plot is disregarded and a proportionate acreage is adopted, calculated from the spacing and from the number of palms in each group. To convert the yield of fruit (or bunches) per acre into yields of mesocarp oil and kernels, for the table B of each plot, the actual average percentages of oil and kernels are used which were obtained over a period of two years when the cooker-press was in operation at Calabar. These figures were published in Table I. of the first paper. The efficiency of the cooker-press, for fruit of the ordinary thick-shell type, was originally given by Barnes (2) as 63.5 *per cent.* This figure was quoted in the first paper but later work by Manlove and Watson has shown that Barnes underestimated the efficiency of this process. These workers have found the efficiency of the cooker-press process for ordinary thick-shell fruit to be in the neighbourhood of from 75 to 80 *per cent.*

Plot 4—Tables A and B.

Planted in a modified square planting system approximately 20 feet square.

Table A.

186 Okporo (Thick-shell) Trees.

1	2	3	4	5	6	7	8	9	10
Year.	Number of bunches.	Weight of bunches in lb.	Average weight per bunch in lb.	Weight of fruit in lb.	Average weight of fruit per bunch in lb.	Percentage fruit weight to bunch weight.	Average number of bunches per tree.	Average weight of bunches per tree in lb.	Average weight of fruit per tree in lb.
1922	446	4,799	10·8	...	...	...	2·4	25·8	...
1923	632	7,128	11·3	...	...	...	3·4	38·3	...
1924	624	8,734	14·0	5,602	9·0	64·2	3·4	47·0	30·1
1925	593	8,936	15·1	6,015	10·1	67·5	3·2	48·1	32·4
1926	453	7,434	16·4	4,824	10·6	65·0	2·4	40·0	26·0
1927	410	7,680	18·7	4,904	12·0	64·0	2·2	41·3	26·4
1928	506	8,902	17·6	5,799	11·5	65·2	2·7	47·8	31·2
1929	552	10,760	19·5	7,040	12·8	65·5	3·0	57·8	37·8
1930	478	9,612	20·1	6,116	12·8	63·5	2·6	51·7	32·9
Average 1922–30	522	8,221	15·8	5,757	11·1*	65·0*	2·9	44·2	31·0*

Note:—The figures marked by an asterisk in the above table are the averages for the period 1924–30.

PLOT 4—*continued.*

64 Osok (Thin-shell) Trees.

1922	149	1,394	9·4	...	...	...	2·3	21·8	...
1923	166	1,785	10·8	...	...	...	2·6	27·9	...
1924	203	2,537	12·5	1,421	7·0	56·0	3·2	39·5	22·2
1925	165	2.231	13·5	1,290	7·8	58·0	2·6	34·9	20·2
1926	137	2,187	16·0	1,150	8·4	52·5	2·1	34·2	18·0
1927	112	1,933	17·3	1,052	9·4	54·5	1·8	30·2	16·4
1928	164	2,801	17·1	1,676	10·2	60·0	2·5	43·1	26·2
1929	204	3,761	18·4	2,192	10·7	58·1	3·1	57·9	33·7
1930	189	3,582	19·0	2,010	10·6	56·0	3·0	56·0	31·4
Average 1922–30	165	2,468	15·0	1,542	9·2*	56·5*	2·6	38·6	25·0*

Note:—The figures marked by an asterisk in the above table are the averages for the period 1924–30.

Table B.

Okporo (Thick-shell). Area≡1.815 Acres.

1	2	3	4	5	6	7
Year.	Number of years since plot planted out.	Number of bunches per acre.	Weight of bunches per acre in lb.	Weight of fruit per acre in lb.	Weight of mesocarp oil per acre in lb.	Weight of kernels per acre in lb.
1922	10	246	2,645	...	291	174
1923	11	348	3,930	...	432	259
1924	12	344	4,820	3,085	525	318
1925	13	327	4,920	3,315	563	341
1926	14	250	4,100	2,660	452	274
1927	15	226	4,230	2,700	459	278
1928	16	279	4,910	3,195	543	329
1929	17	304	5,930	3,880	659	399
1930	18	263	5,290	3,370	573	347
Avarage 1922–30	10–18	288	4,530	3,170*	498	299

Osok (Thin-shell). Area≡0.624 Acres.

1922	10	239	2,235	...	342	69
1923	11	266	2,860	...	437	89
1924	12	325	4,070	2,280	630	128
1925	13	264	3,580	2,065	572	116
1926	14	220	3,505	1,840	510	103
1927	15	179	3,100	1,685	466	94
1928	16	263	4,490	2,685	745	150
1929	17	327	6,030	3,510	970	197
1930	18	303	5,740	3,220	890	182
Average 1922–30	10–18	264	3,950	2,470*	605	123

Note:—The fruit figures marked by an asterisk are the averages for the period 1924-30.

Plot 4 is planted at a nominal spacing of 20 feet square (not triangular as was erroneously stated in the first paper). A modified square planting system was adopted when this block was laid out and adjacent rows of palms were staggered. But the actual density of palms per acre is less than it should be at this spacing, on account of some of the distances between palms exceeding 20 feet. The average area occupied by each palm is 425 square feet and this figure is used in calculating the proportionate acreages for the plot. The yields of 186 Okporo and 64 Osok palms are included for plot 4. The calculated acreages are :—

186 Okporo palms	1.815 acres.
64 Osok palms	0.624 acres.

The percentage yields of mesocarp oil and kernels used in compiling Table B for plot 4 are :—

	Okporo palms.	*Osok palms.*
Mesocarp oil—to fruits	17.0 *per cent.*	27.7 *per cent.*
—to bunches ...	11.0 ,, ,,	15.3 ,, ,,
Kernels —to fruits	10.3 ,, ,,	5.6 ,, ,,
—to bunches ...	6.6 ,, ,,	3.1 ,, ,,

The average density of plot 4 is 102.5 palms per acre. As is to be expected from the spacing individual tree yields are low, but the yields per acre, while well below those recorded for the more widely planted plots, are better than would be anticipated from a casual inspection of plot 4. In appearance the palms of this plot are distinctly inferior to those of the other plots. Tables A and B show marked fluctuations of the annual yields, but the figures indicate a tendency of the yields to increase over the period 1922-30. That is from the tenth to the eighteenth year after the planting up of the plot. Plot 4 presents a useful comparison between the yields of the ordinary thick-shell (Okporo) and the ordinary thin-shell (Osok) fruit forms. The figures show that the thin-shell palms have given approximately 87 *per cent.* and 78 *per cent.* of the respective average yields of bunches and fruits, per acre, recorded for the thick-shell palms. Taking the average yields of fruit per acre for the period 1924-30, in terms of mesocarp oil and kernels (obtainable by the cooker-press process); and assuming the value of kernels to be 58 *per cent.* of the value of soft oil [the average over the period 1922-29. as given in the Nigeria Blue Books (3)]; the average values of the mesocarp oil and kernels produced by the thick-shell and thin-shell palms are 727 and 764 units respectively. A critical comparison between the values of these two fruit forms is made later.

Plot 6—Tables A and B.

Planted 30 feet square.

TABLE A.

125 Okporo (thick-shell) Trees.

1	2	3	4	5	6	7	8	9	10
Year.	Number of bunches.	Weight of bunches in lb.	Average weight per bunch in lb.	Weight of fruit in lb.	Average weight of fruit per bunch in lb.	Percentage fruit weight to bunch weight.	Average number of bunches per tree.	Average weight of bunches per tree in lb.	Average weight of fruit per tree in lb.
Average 1922–28 ...	741	13,432	18·1	9,140	13·0	65	5·9	107·5	73
1929 ...	690	17,718	25·7	11,571	16·8	65·5	5·5	142	92·5
1930 ...	672	17,897	26·6	10,976	16·3	61·5	5·4	143·2	87·8

8 Osok (thin-shell) Trees.

Average 1922–28 ...	40	643	16·1	352	8·8	56	5·0	80	44
1929 ...	47	801	17·0	447	9·5	56	5·9	100	55
1930 ...	59	947	16·1	507	8·6	53·5	7·4	118·4	63·4

TABLE B.

Okporo (thick-shell). Area≡2.583 Acres.

1	2	3	4	5	6	7	8
Year.	Number of years since plot planted out.	Number of trees for which yields are included.	Number of bunches per acre.	Weight of bunches per acre in lb.	Weight of fruits per acre in lb.	Weight of mesocarp oil per acre in lb.	Weight of kernels per acre in lb.
Average 1922–28 ...	10–16	125	287	5,199	3,538	587	333
1929	17	125	267	6,860	4,480	788	448
1930	18	125	260	6,930	4,250	748	425

Osok (thin-shell). Area≡0.165 Acres.

Average 1922–28 ...	10–16	8	242	3,897	2,133	549	144
1929	17	8	285	4,855	2,710	685	180
1930	18	8	356	5,750	3,075	810	213

Plot 10—Tables A and B.

Planted 25 feet square.

TABLE A.

1922-29 = 220
1930 = 217
} Okporo (thick-shell) Trees.

1	2	3	4	5	6	7	8	9	10
Year.	Number of bunches.	Weight of bunches in lb.	Average weight per bunch in lb.	Weight of fruit in lb.	Average weight of fruit per bunch in lb.	Percentage fruit weight to bunch weight.	Average number of bunches per tree.	Average weight of bunches per tree in lb.	Average weight o fruit per tree in lb.
Average 1922–28 ...	1,076	20,329	18·9	12,975	13·3	64·5	4·9	92·5	59
1929 ...	888	22,335	25·1	14,274	16·1	64	4·0	101	64 5
1930 ...	968	24,377	25·2	15,755	16·3	64·7	4·5	113·2	72·6
17 Osok (thin-shell) Trees.									
Average 1922–28 ...	81	1,443	17·8	796	11·1	51·9	4·8	85	47
1929 ...	84	1,846	22·0	1,074	12·8	58	4·9	108·5	63·5
1930 ...	92	2,197	23·9	1,207	13·2	55·0	5·4	129·4	71·0

TABLE B.

Okporo (thick-shell). Area { 1922-29 ≡ 3.156 Acres.
1930 ≡ 3.113 Acres.

1	2	3	4	5	6	7	8
Year.	Number of years since plot planted out.	Number of trees for which yields are included.	Number of bunches per acre.	Weight of bunches per acre in lb.	Weight of fruits per acre in lb.	Weight of mesocarp oil per acre, in lb.	Weight of kernels per acre in lb.
Average 1922–28 ...	9–15	220	341	6,441	4,111	734	445
1929	16	220	281	7,075	4,524	805	489
1930	17	117	311	7,870	5,060	901	546
Osok (thin-shell). Area ≡ 0.244 Acres.							
Average 1922–28 ...	9–15	17	332	5,913	3,262	845	195
1929	16	17	344	7,550	4,410	1,080	250
1930	17	17	377	9,010	4,950	1,290	297

Abbreviated tables are given for plots 6 and 10 and include the data for the years 1929 and 1930, together with averages over the period 1922-28 for comparison. The figures for the period 1922-28

were published in full in the first paper. The yields recorded for both plots during the two past seasons are well above the averages for the earlier period of years. Fluctuations in the yields of these plots have occurred before, so that it cannot yet be inferred from the latest figures that the yields are increasing; although there is some indication that this may be so. In plot 10 three ordinary thick-shell (Okporo) palms died during 1930. Therefore the number of palms of this group, of which yields are included is reduced from 220 to 217 and a proportionate reduction is made in the calculated acreage of this group of palms for 1930.

Plot 11—Tables A and B.

Planted 25 feet square.

TABLE A.

20 Ayara Mbana (Mantled type—thick-shell) Trees.

1	2	3	4	5	6	7	8	9	10
Year.	Number of bunches.	Weight of bunches in lb.	Average weight per bunch in lb.	Weight of fruit in lb.	Average weight of fruit per bunch in lb.	Percentage fruit weight to bunch weight.	Average number of bunches per tree.	Average weight of bunches per tree in lb.	Average weight of fruit per tree in lb.
Average 1922–28 ...	188	2,129	11·3	1,298	6·7	52·5	9·4	106·4	64·9
1929 ...	162	2,740	16·9	1,403	8·7	51·2	8·1	137·0	70·1
1930 ...	155	2,793	18·1	1,438	9·3	51·5	7·7	139·6	71.9
4 Ayara Mbana (Mantled type—thin-shell) Trees.									
Average 1922–28 ...	39	378	9·7	128	4·3	33·9	9·7	94·5	32
1929 ...	30	362	12·1	125	4·2	34·5	7·5	90·5	31·2
1930 ...	27	353	13·1	140	5·2	39·5	6·7	88·2	35·0
21 Okporo (thick-shell) Trees.									
Average 1922–28 ...	146	1,638	11·2	1,164	8·3	64	6·9	78	55·5
1929 ...	124	2,487	20·1	1,548	12·5	62·5	5·9	118·5	73·5
1930 ...	94	2,064	22·0	1,288	13·7	62·4	4·5	98·3	61·4
7 Osok (thin-shell) Trees.									
Average 1922–28 ...	60	693	11·5	412	7·3	54·5	8·6	99	58·5
1929 ...	49	1,046	21·3	561	11·5	53·5	7·0	149·4	80·2
1930 ...	44	941	21·4	513	11·7	54·6	6·3	134·4	73·3

PLOT 11.—*continued.*

TABLE B.

AYARA MBANA (MANTLED TYPE—THICK-SHELL). AREA≡0.287 ACRES.

1	2	3	4	5	6	7
Year.	Number of years since plot planted out.	Number of bunches per acre.	Weight of bunches per acre in lb.	Weight of fruit per acre in lb.	Weight of mesocarp oil per acre in lb.	Weight of kernels per acre in lb.
Average 1922–28 ...	7–13	654	7,408	4,517	919	333
1929 ...	14	565	9,540	4,890	1,183	430
1930 ...	15	540	9,730	5,010	1,260	440

AYARA MBANA (MANTLED TYPE—THIN-SHELL). AREA≡0.057 ACRES.

Average 1922–28 ...	7–13	684	6,631	2,245	729	153
1929 ...	14	525	6,360	2,190	699	146
1930 ...	15	474	6,200	2,450	680	143

OKPORO (THICK-SHELL). AREA≡0.301 ACRES.

Average 1922–28 ...	7–13	485	5,438	3,865	544	316
1929 ...	14	412	8,265	5,145	925	537
1930 ...	15	312	6,860	4,280	768	445

OSOK (THIN-SHELL). AREA=0.100 ACRES.

Average 1922–28 ...	7–13	600	6,930	4,120	991	236
1929 ...	14	490	10,460	5,610	1,516	355
1930 ...	15	440	9,410	5,130	1,360	320

Plot 12—Tables A and B.

Planted 25 feet square.

TABLE A.

6 Afia Oku (Green-fruited—thick-shell) Trees.

1	2	3	4	5	6	7	8	9	10
Year.	Number of bunches.	Weight of bunches in lb.	Average weight per bunch in lb.	Weight of fruit in lb.	Average weight of fruit per bunch in lb.	Percentage fruit weight to bunch weight.	Average number of bunches per tree.	Average weight of bunches per tree in lb.	Average weight of fruit per tree in lb.
Average 1922–28 ...	40	1,031	26·0	707	19·5	62·5	6·7	171·8	117·8
1929 ...	53	1,720	32·4	*910	—	—	8·8	286·7	—
1930 ...	18	710	39·5	457	25·4	64·3	3·0	118·3	76·2

7 Afia Oku (Green-fruited—thin-shell) Trees.

Average 1922–28 ...	49	884	18·2	615	12·3	57·5	7·0	126·3	87·9
1929 ...	60	1,497	25·0	*633	—	—	8·6	213·9	—
1930 ...	31	694	22·4	*321	—	—	4·4	99·1	—

10 Okporo (thick-shell) Trees.

Average 1922–28 ...	58	1,266	21·9	946	15·8	62·5	5·8	126·6	94·6
1929 ...	83	2,675	32·2	1,642	19·8	61·5	8·3	267·5	164·2
1930 ...	47	2,006	42·7	1,314	28·0	65·5	4·7	200·6	131·4

4 Osok (thin-shell) Trees.

Average 1922–28 ...	24	474	20·1	282	11·9	53·5	5·9	118·5	70·5
1929 ...	31	852	27·5	*360	—	—	7·7	213	—
1930 ...	21	463	22·0	*224	—	—	5·2	115·7	—

Note—The fruit weights marked by an asterisk are too low and unreliable on account of the interference due to selfing.

TABLE B.

AFIA OKU (GREEN-FRUITED—THICK-SHELL). AREA≡0.086 ACRES.

1	2	3	4	5	6	7
Year.	Number of years since plot planted out.	Number of bunches per acre.	Weight of bunches per acre in lb.	Weight of fruit per acre in lb.	Weight of mesocarp oil per acre in lb.	Weight of kernels per acre in lb.
Average 1922–28 ...	7–13	465	11,989	8,222	1,343	575
1929 ...	14	616	20,000	–	2,240	960
1930 ...	15	210	8,250	5,320	925	395

AFIA OKU (GREEN-FRUITED– THIN-SHELL). AREA≡0.100 ACRES.

Average 1922–28 ...	7–13	490	8,840	6,150	1,627	354
1929 ...	14	600	14,970	—	2,750	600
1930 ...	15	310	6,940	—	1,270	277

OKPORO (THICK-SHELL). AREA≡0.143 ACRES.

Average 1922–28 ...	7–13	406	8,849	6,614	991	575
1929 ...	14	580	18,720	11,480	2,095	1,216
1930 ...	15	329	14,030	9,190	1,570	910

OSOK (THIN-SHELL). AREA≡0.057 ACRES.

Average 1922 28 ...	7–13	421	8,314	4,916	1,206	283
1929 ...	14	544	14,960	–	2,168	508
1930 ...	15	370	8,120	--	1,180	276

The data for plots 11 and 12, for 1929 and 1930, is presented similarly in abbreviated tables. For plot 11, with the exception of the mantled thin-shell (Ayara Mbana) fruit form, the yields for these past two years are well above the previous averages; but again it is not yet possible to say that this is anything but the result of normal fluctuation. The figures for plot 12 illustrate the fluctuations in yield. During 1929 all groups in this plot gave exceptional yields with that of the best group, the green-fruited thin-shell (Afia Oku) fruit form, a yield of over 24 cwt. of mesocarp oil, plus over five cwt. of kernels, per acre (obtained on the cooker-press basis of extraction). Admittedly, this is calculated from the yields of only seven mature palms, but the mature palms of the other three groups in plot 12 all gave a ton, or just under, of mesocarp oil during 1929

which endorses the reliability of the figures. All these palms are the progeny of an unselected and unrecorded bush parent palm and the results are encouraging, and suggest that considerable improvement may be achieved by selection. During 1930 much lower yields are recorded and, with the exception of the yield of the ordinary thick-shell (Okporo) group, are below the averages for the period 1922-28. This is undoubtedly due partly to normal fluctuation, with small groups of palms greater variation in the annual yields is to be expected than with large groups, and partly to the interference caused by the breeding work that has been in progress at Calabar since the beginning of 1928. Breeding involves a strain on the palm on account of the severe pruning that is necessary in order that the inflorescences may be bagged. Further, some immature female inflorescences must be removed and thus the yield is somewhat reduced. The proportion of palms selected for breeding in the groups of plot 12 is much higher than in other plots, and the effect of the interference with yield is not averaged over a large number of palms in this instance. The yields from plots 11 and 12 must be accepted with the reservation that these provide an indication only of the potential yield per acre of the green-fruited (Afia Oku), and of the mantled (Ayara Mbana), types, as the number of mature palms in each group is so small.

Discussion of the Yields.

The original data of the yields of the Calabar plantation palms, published in a first paper (I), has been supplemented by the addition of the yields of the closely spaced plot 4, and by the yields for two further years, 1929 and 1930, of the other four plots. The figures published for the Calabar palms show that the yields of mature plantation palms are subject to considerable annual variation. A plantation of palms appears to approach the maximum yield about ten years after planting out. This is the view of Ives Henri, quoted by Waters (4); and the most recent Sumatran literature available (5) suggests that the maximum yield is attained from ten to twelve years after the palms are planted out. The Calabar oil palm yields reached a peak about 1924 to 1925, between 11 and 13 years after planting, then fell to reach a general low level about 1927, and have since again risen to a peak in 1929; although for some groups the second peak was only attained in 1930. The general level of the yields of all plots was higher for the period of the second peak than for the period of the first. Thus there is some indication that the yields of these palms may be increasing slightly after the tenth to twelfth year since planting out. Inspection of the tables suggests that another temporary fall in yield may be now commencing.

Comparison with other Yields.

Deighton (6) gives the yield of a mixed plantation of thick and thin-shell palms grown from Nigerian seed at Njala as 3,160 lb. of fruit per acre for the eighth year after planting out. These palms had obviously not then reached their maximum yield, but it appears unlikely from this figure that the yields at Njala will surpass those of the Calabar palms. The yields for the Gold Coast palms, recently published by Williams (7), are hardly comparable with Calabar yields. Schmole (lit. cit.) gives an average yield of 220 lb. of bunches per tree for Deli palms when in full bearing. This is for palms twelve years old and planted at a triangular spacing of nine meters. He quotes Blommendaal as giving the content of mesocarp oil as from 16 to 17 *per cent.* of the bunch weight (28 to 29 *per cent.* of the fruit weight, plus seven to eight *per cent.* of the fruit weight as the yield of kernels). This is equivalent to a yield of 2,035 to 2,165 lb. of mesocarp oil, plus 500 lb. of kernels, per acre. It is possible that this yield of mesocarp oil rather overestimates the amount recovered by commercial extraction. Further, it is probable that such average yields are not obtained over all large commercial plantations. Certain Calabar yields are quoted in comparison, these may be said to be based on an extraction efficiency of approaching 80 *per cent.* :—

Plot, Year and Type of Fruit.	Yields per Acre.	
	Mesocarp Oil in lb.	Kernels in lb.
Plot 10—1930—ordinary thick-shell	901	546
—ordinary thin-shell	1,290	297
Plot 11—1930—mantled thick-shell	1,260	440
—1929—ordinary thin shell	1,516	355
Plot 12—1929—ordinary thick-shell	2,095	1,216
—green-fruited thick-shell	2,240	960
—green-fruited thin-shell	2,750	600
Sumatran Average—Deli type palms in full bearing.	2,035 to 2,165	500

Annual yields in place of average yields are included in the above table to show that yields equal to those recorded in Sumatra have been obtained at Calabar. When a comparison is made between Nigerian and Sumatran yields, it must not be forgotten that there is only a total area of some eight acres of plantation palms at Calabar, that have not grown under the most favourable circumstances, as opposed to a very large acreage in Sumatra from which the better individuals and areas probably tend to be selected as

examples. This seems to be a very material point, the data from the limited area of palms at Calabar is being compared with results chosen from the very large population of plantation palms growing in Sumatra. Further, the Calabar palms are grown from the seed of unselected bush parent trees while, as the Dutch writers admit, Sumatra was fortunate enough to start with definitely superior material for her first oil palm plantations. But this in no way minimises the fact that the Deli type of palm undoubtedly gives excellent results in Sumatra, and that generally very satisfactory plantation yields are obtainable in the East. Not only does the Deli type of palm give a very high average yield of fruit per tree but, whereas Manlove gives the average oil content of the ordinary thick-shell Nigerian fruit as about 23 *per cent.*, Schmole (lit. cit) gives the oil content of the Deli type fruit as from 28 to 29 *per cent.* The average yields of kernels are ten and a half *per cent.* of the weight of fruit for the Nigerian ordinary thick-shell form, and seven to eight *per cent.* of the weight of fruit for the Deli type. Thus the fruit of the Deli type yields approximately five to six *per cent.* more oil and three *per cent.* less kernels than the fruit of the ordinary thick-shell Nigerian palms. Taking the value of kernels as 58 *per cent.* of the value of soft oil, the Deli type palm produces at least four *per cent.* more in unit value of saleable produce, from a given weight of fruit, than does the ordinary thick-shell Nigerian palm. The Nigerian ordinary thin-shell, green-fruited thin-shell, and mantled thick-shell, fruit forms have all an oil content equal to, or higher than, that of the Deli type. As was described in the first paper, breeding has been commenced and all types will be tested with a view to the production of improved seed for planting and, ultimately, of superior strains of the oil palm.

Value of the Ordinary Thick and Thin-shell Sub-types.

The comparative values of the ordinary thick (Okporo) and thin-shell (Osok) sub-types do not depend alone upon the respective oil contents of the fruits. The values also depend upon the yields of fruit per acre, and upon the proportions of the total oil content of the fruits that can be recovered by any given extraction process. The figures published for yields per tree and yields per acre, in the tables A and tables B, show that, with the exception of plot 11, the yields of the ordinary thick-shell palms consistently exceed the yields of the ordinary thin-shell palms. Deighton's figures, for the yield recorded for the Nigerian oil palm plantation at Njala, show a similar excess in the yield of fruit for thick-shell over thin-shell palms (6). It is difficult to assess accurately the extra yield given by the thick-shell palms as none of the mixed thick and thin-shell plots can be taken as completely reliable experiments for measuring this difference in yield. The following figures are available :—

Plot and Period for which Yields are compared.	Yield per Acre of Ordinary Thick-shell Palms expressed as a percentage of the Yield per Acre of Ordinary Thin-shell Palms.
Plot 4—average 1924–30	128
Plot 6—average 1924–28	166
Plot 10—average 1924 and 1926–28	126
Plot 11—average 1924–28	55
Plot 12—average 1924–28	134
Njala—average 1926–28	125

From the data given in the above table it seems probable that, with unselected oil palm seed, the yield per tree, and therefore per acre, of the ordinary thick-shell palms is at least 25 *per cent* greater than the respective yields of the ordinary thin-shell palms. Assuming a 25 *per cent.* additional yield to be a correct estimate for ordinary thick-shell palms, the following table shows the return from the fruit of the two sub-types, expressed in unit value of saleable produce, for the two extraction processes:—

Type and Weight of Fruit Treated.	Weight of Mesocarp Oil in lb.	Weight of Kernels in lb.	Kernels as 58% Mesocarp Oil.	Total Unit Value as Saleable Produce.
(I) Extraction by Native Washing Process—Efficiency about 65%.				
Thick-shell fruit (100 lb.) ...	10·9	10·8	6·3	17·2
Thick-shell fruit (125 lb.) ...	13·6	13·5	7·8	21·4
Thin-shell fruit (100 lb.) ...	14·1	7·0	4·1	18·2
(II) Extraction by Cooker-Press Process—Efficiency 75–80%.				
Thick-shell fruit (100 lb.) ...	17·5	10·4	6·0	23·5
Thick-shell fruit (125 lb.) ...	21·9	13·0	7·5	29·4
Thin-shell fruit (100 lb.) ...	27·6	6·6	3·8	31·4

Note.—In compiling the above table the average figures, *see* Table I of the first paper, of mesocarp oil and kernels for the two extraction processes are used and, in calculating the unit value of the produce, kernels are assumed to be worth 58 *per cent.* of the value of soft oil.

From the above table it is seen that if the oil palm fruit is to be extracted by a native process—(such processes are likely to have an extraction efficiency approaching that of the particular native washing process described in the first paper)—and if the figure for the difference in yield of the two sub-types is approximately correct, then the thick-shell form is definitely superior. Even if the yields

are equal, which from the present figures seems to be most unlikely, the thin-shell fruit form is only just superior to the thick-shell fruit form with native methods of oil extraction. With the cooker-press process of oil extraction the thin-shell form is just superior, or in the event of a difference of less than 25 *per cent.* in the yields, definitely superior. Assuming factory extraction, with a greater efficiency than that of the cooker-press, the thin-shell form is undoubtedly superior. But factory extraction, as the general process, is at the present time a very remote contingency in Nigeria.

This comparison, between the ordinary thick and thin-shell forms, is of importance in view of the suggestion, that has been repeatedly advanced, that the native farmer should be taught to plant seed of thin-shell palms. With uncontrolled pollination the thin-shell form is known not to breed true; although the results from plot 4 at Calabar, and from the Nigerian oil palm plot at Njala (Deighton, lit. cit.), both planted with seed of thin-shell palms, have shown that the proportion of thin-shell palms could be very much increased by planting such seed. Assuming as has been done, an ordinary relation between the prices of oil and kernels, the desirability of the thin-shell form depends upon the proportion of the oil that can be extracted. The comparison has shown that immediate propaganda for the planting of thin-shell seed would be mistaken. It has been shown that the yield of fruit is of equal importance with a high oil content. The value of some such process as is provided by the cooker-press, whereby the native farmer can approach the efficiency of factory extraction, is illustrated; and the development of this improved process, for the extraction of oil by the native farmer, is seen to be a necessary corollary to the production of strains of palms with a thin-shell form of fruit having a high oil content.

Summary.

The conclusions from the study of the yields of the Calabar plantation palms, published in this and a previous paper, may be summarised as follows:—

1. That the yields of mesocarp oil obtained from three areas (plots 4, 6 and 10) of the ordinary thick-shell Nigerian palm, growing at Calabar and planted at different spacings, are rather less than half the yields of mesocarp oil said to be obtained from the Deli type in Sumatra. This lower yield is accounted for by a lower yield of fruit per palm, a lower yield of mesocarp oil from the fruit, and by the fact that none of the Calabar plots were planted at the optimum spacing. If the estimated Sumatran yields of Ives Henri

(4) are taken, these Calabar palms compare more favourably with the Deli type, the lower yield in this instance may be accounted for by the higher oil content of the Deli fruit and by the Calabar spacings.

2. That the small groups of palms in plot 12, and to a lesser extent in plot 11, have given yields that compare very favourably with Sumatran figures. The yield figures, in conjunction with press extraction, suggest that the green-fruited thin-shell (Afia Oku) palm is the most promising, but that the best trees of all types are capable of giving very high yields. The yield of the mantled thin-shell (Ayara Mbana) fruit form is adversely affected by the low proportion of fruit to bunch.

3. That the merits of the ordinary thin-shell palm, as opposed to those of the ordinary thick-shell palm, depend upon the yield of fruit per palm and upon the proportion of the mesocarp oil that can be extracted from the fruit. With native methods of oil extraction, and with the observed differences between the yields of these two sub-types, the ordinary thick-shell form is the more valuable. With an improved method of oil extraction, having the efficiency of the cooker-press, the ordinary thin-shell form is slightly the more valuable, and definitely so with factory extraction. The yield of fruit per palm and the oil content of the fruit are of equal importance.

4. That the possibility of growing thin-shell palms with a high oil content on native plantations will depend entirely upon the successful development of the cooker-press process, or of some similar improved method for oil extraction by native farmers. Without such a process thin-shell palms are less valuable than thick-shell palms, on account of the lower yield of fruit per palm, of the low proportion of the oil of thin-shell fruit that is recovered by native extraction methods, and of the lower yield of kernels from the thin-shell fruit.

5. That the cooker-press process of oil extraction gives an increase of approximately 50 *per cent.* over the native washing method for the fruit of the ordinary thick-shell, and green-fruited thick-shell, palms. For the fruit of the mantled thick-shell palms, and for all the thin-shell forms, the increase, obtained with the cooker-press, is in the neighbourhood of 100 *per cent.*

6. That the optimum spacing for oil palms at Calabar is in the neighbourhood of 27 to 28 feet for the square planting, and of 29 feet for triangular planting.

7. That the maximum yield of a plantation of oil palms is reached from 10 to 12 years after planting out. In the succeeding years marked annual fluctuation of yield occurs. The rise and fall in yield, occasioned by this fluctuation, appears to follow a curve. Good years seem to be followed by moderate years, then poor years followed by moderate years again. There is some indication that, on the average, the yield tends to increase slightly after the tenth to twelfth year from planting.

8. As the palms increase in age, fewer and heavier bunches are produced.

9. A plantation of palms from unselected seed presents great variation in the yield of individual trees. A few give an excellent yield, the majority a medium yield, but a considerable proportion of the palms give little or no yield.

10. While a poor average yielding palm does not produce a high yield in any single year, medium average yielding palms can produce a very high yield, and high average yielding palms a very low yield, in a single year. A very high yield during one year from an individual palm is often followed by a very low yield the following year.

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PRESS EXTRACTION OF PALM OIL IN NIGERIA.

By D. MANLOVE, B.SC. AND W. A. WATSON, B.SC.

The work carried out by A. C. Barnes* and others, prior to 1928, on the extraction of palm oil by native farmers may be summarized as follows :—

(*a*) An examination was made of the two principal existing native methods, known as the " Soft Oil " and " Hard Oil " processes. Their efficiency was estimated as 45-50 *per cent.*

(*b*) A modified process intended to combine the better features of the two native methods was evolved and put into practice : it was, however, found to be incapable of quite the same efficiency as the Soft Oil method, though an improvement on it in that somewhat less labour was required.

(*c*) Experiments were made with hand-screw-presses of cage capacity about five gallons : these were usually carried out in conjunction with a rather elaborate fruit boiler or steamer imported from England, although the use of an apparatus made from used tar-drums was suggested for this purpose. The efficiency of this " Cooker-Press " process is given as 65 *per cent.* : the considerable expense of the apparatus (about £40) is regarded as a serious disadvantage.

(*d*) An examination was made of the causes and means of prevention of hydrolysis of palm oil during extraction. The former was traced to a lipase contained in the pulp which was found to be destroyed at 55°C, or—with greater certainty and ease—by boiling or steaming the fruit.

(*e*) The various large scale (factory) extraction methods were investigated, and the applicability of each to the Nigerian industry discussed. Centrifugal methods were regarded as greatly preferable to hydraulic expression.

The general conclusion reached appeared to be that Nigerian farmers were unlikely to make a success of a semi-works-scale extraction plant, and that there was no alternative to the European-controlled factory except the simplest of hand-methods such as the existing native methods or the " Cooker Press " process.

* (Annual Bulletins of the Agricultural Dept., Nigeria, 1924 and 1926). (Special Bulletin of the Agricultural Dept., Nigeria, 1924).

Since the publishing of this work, the likelihood of the establishment of further oil mills (or factories) in Nigeria in the near future has become considerably less. In the coastal area of the mandated Cameroons territory, a number of such mills are in existence, and are supplied from privately owned plantations: at Ibagwa in Calabar Province, the only other such mill in Nigeria, owned by the United Africa Company, depends on purchase from surrounding farmers for its supply of fruit; and has recently been closed down.

The relative merits of large-and small-scale production have been frequently discussed: the better features of the latter are, of course, the very small initial outlay, the resulting freedom from such "overhead" costs as interest on capital or depreciation of stock, and the cheap labour, which can readily be transferred to other work in times of stress. By means of this flexibility a small-scale industry is well adapted to meet changes in economic conditions such as the recent world-wide slump in commodity prices. As against this, the small native farmers' production methods are usually inefficient: in the case of palm oil production, the inefficiency is notorious.

Such considerations suggested that the line of investigation offering most promise of progress was a continuation of Barnes' later work on small-scale methods, with the ultimate object of introducing one retaining as far as possible their natural advantages, but capable of greater efficiency. The former object was considered to be as important as the latter. It means simply that the cost of any apparatus which has to be used must be as little as possible, and that "efficiency" must be estimated in terms of the ratio of labour to yield.

Yield Efficiency of Hand Press.

Initial experiments were made with the Culley-Ducolson type hand-screw press described by Barnes (Bulletin 1926): it has a cage capacity of about five gallons and develops a pressure of some 4-6 cwt. per square inch. Using this machine, the following are typical analyses of palm fruit *pulp* before and after pressing:—

Before Pressing.			After Pressing.			Yield Efficiency.
Oil.	Water.	Fibre.	Oil.	Water.	Fibre.	
49·2	33·4	17·4	20·6	38·0	41·4	82·4
51·8	31·4	16·8	19·4	44·6	36·0	82·5
48·0	34·1	18·0	19·3	41·5	39·2	81·5
45·2	36·6	18·2	17·5	39·5	43·0	83·6
51·4	31·1	17·4	20·7	38·2	41·1	83·0
46·4	37·3	16·3	20·9	37·5	41·6	82·3
Mean 48·4	34·2	17·4	19·8	39·8	40·4	82·5

These results were obtained with two pressings of the pulp and may be regarded as " practical " yields: efficiencies approaching 90 *per cent.* may be obtained by means of 3rd and 4th pressings, but only at the expense of a high labour-to-yield ratio.

Extraction of Whole Fruit.

Yields such as those recorded in the preceding paragraph are obtained by pressing nut-free pulp: as soon, however, as any attempt is made to press the whole fruit of the common thick-shelled variety, it is found that equally good results cannot be obtained, in as much as the nuts come into contact with each other before the full pressure of the press has been applied to the pulp. That is to say the volume of the fully-compressed pulp is insufficient to fill what may be termed the " pore space " of the nuts, and the nuts being incompressible, the total volume of this pore space represents the limit of possible compression of the pulp. The extent to which this effect occurs depends of course only on the relative proportions of pulp and nuts in the fruit which is to be pressed.

The determination of the " pore space " therefore becomes of importance: such experiments are very simply made, but, in order to express the volume readings in terms of weight ratios of pulp and nuts, it is of course necessary to determine also the specific gravity of the nuts and of the compressed pulp. The following are representative of a considerable number of determinations:—

Sp. Gravity of Compressed Pulp.	Sp. Gravity of Nuts.	Pore Space of Nuts.	
		Loose Packed.	Tight Packed.
		%	%
1·140	1·238	40·3	35·4
1·138	1·228	40·0	35·6
1·149	1·240	39·9	34·0
1·158	1·250	40·1	35·9
1·153	1·256	40·6	35·6
1·134	1·237	41·1	34·4
Mean 1·145	1·242	40·3	35·2

The " Pore-Space " figures are percentages to the total volume occupied by nuts (*i.e.* volume of nuts + volume of pore space). The corresponding pore space of perfect spheres may be calculated to be

for loosest possible packing ... ... 47.64 *per cent.*
,, tightest ,, ,, ... 25.94 ,, ,,

By calculation from these figures and the average analyses of pressed pulp, it is found that the minimum proportion of pulp permitting of the effective application of the full pressure of 6 cwt.

per square inch is,

if the nuts be assumed loosely packed ... 58.0% } by weight
,, ,, ,, tightly ,, ... 52.7% }

to fruit. Naturally, if greater pressures are to be applied, still higher proportions of pulp to fruit will be required.

The nature of the packing adopted by the nuts has been determined to some extent by volume measurements of mashed fruit under pressure, and has been found to depend a little on the moisture content of the pulp, as follows:—

Added Water % to fruit.	Volume of Compressed Pulp.		Actual Nut-Pore-Space.
	Calcd. at 40·3% Nut Pore Space.	Found.	
			%
8	329·0 litres	346·2 litres	42·4
10	111·9 ,,	111·2 ,,	40·1
16	148·9 ,,	145·7 ,,	39·6

From this it will be seen that, unless the pulp is very wet indeed, the nuts cannot be expected to pack closely on pressing, and therefore, in order to realise the possible efficiency of the press when the whole fruit is pressed it is necessary that the fruit should contain at least 58-60 *per cent.* of pulp by weight.

Proportion of Pulp in Nigerian Fruit.

Below are some analyses of Nigerian palm fruit from various sources: they refer only to the thick-shelled ordinary type (Efik name Okporo Eyop), as this type is at present greatly predominant: the fruit of the thin-shelled ordinary type (Osok Eyop) contains some 75 *per cent.* of pulp by weight, and without difficulty is completely extracted by pressing.

Source.	Month.	Quantity Sampled.	% Pulp to Fruit.
Calabar	September ...	50 fruits ...	46·3
Calabar	March	50 ,, ...	50·8
Oron	October	50 ,, ...	45·5
Azumini	,, ...	50 ,, ...	49·1
Umuahia	,, ...	50 ,, ...	40·5
Umuahia	March	50 ,, ...	45·7
Aba	October	50 ,, ...	38·0
Onitsha	April	50 ,, ...	44·6
Benin	September ...	50 ,, ...	40·1
Benin	April	50 ,, ...	39·2
Cameroons. Ekona ..	October	20 ,, ...	44·0
,, Moliwe ...	,, ...	20 ,, ...	38·7
Ibadan	August–March	Bulk expts. ...	37·8
	April–July ...	,, ,, ...	43·0

In the bulk analyses of thick-shelled fruit on the plantation at Calabar is recorded by Smith (*), the highest mean figure published is 44 *per cent.* The authors are indebted to Mr. Smith for permission to make a detailed examination of these records, from which it was found that the highest mean annual figure observed for a single plot was 51.5 *per cent.*, whilst the figures for individual analyses only very rarely exceed 55 *per cent.* This is of importance, as Calabar is situated in the south-east coastal area where the conditions for the growth of the oil palm appear to be the most favourable in the country.

On this information it is safe to conclude that press extraction of the common variety of Nigerian palm fruit, unless it be preceded by a process for the reduction of the proportion of nuts to pulp, must be incomplete.

On whatever scale the extraction is carried out it will therefore be necessary to adopt one or other of the following alternative procedures:—

(*a*) Some or all of the nuts are removed, and the extraction made by a single pressing of the separated pulp, or a mixture of nuts and pulp.

(*b*) A preliminary pressing is given to the whole mashed fruit, after which the nuts are separated, and the pulp given a second pressing.

On a factory scale process (*a*) requires the use of depulping machinery with the attendant disadvantages of "bottlenecking" the process and loss of oil on the surface of the nuts, whilst if (*b*) is used, the separation will be effected by drying and screening, but the second pressing will mean extra processing for the same yield of oil. These facts strongly support Barnes' contention of the greater suitability of centrifugal extraction methods in Nigeria. They may, also, to some extent explain the notable success obtained with hydraulic presses in Sumatra where the fruit of the predominant "Deli" type oil palm is reported to contain some 60 *per cent.* of pulp.

Separation of Nuts and Pulp.

The necessity of this nut-separation process is, however, a still greater set-back to press extraction on a small scale. The use of depulping machinery, even of the simplest hand-operated type, considerably increases the capital outlay required and constitutes thereby another step away from an ideal native process. These machines are also appallingly laborious when hand-operated, and, inevitably, rapid-wearing; such features as these the native farmer very readily perceives for himself; and, even were confidence felt in the usefulness of these machines by ourselves, it would be impossible to arouse the same feeling in the farmer.

* (Eighth Annual Bulletin of the Agricultural Department, Nigeria, 1929, 5-42).

The opposite alternative of simple hand-picking of the nuts from the pulp, as in the original " Cooker-Press " method, is unfortunately particularly tedious and inefficient: thus four boys require some 40 minutes for the hand separation of 100 lbs. of fruit, and a loss of 10-15 *per cent.* of the pulp on the surface of the nuts is common and unavoidable. Partial recovery of this loss of pulp is possible by washing the nuts with water or rubbing them with dry, extracted fibre, but only at a further heavy cost of time and labour. As a result of this now excessive expenditure of labour on the picking process, the apparent technical superiority of hand pressing to native methods, regarded from the point of view of the ratio of yield to labour, largely disappears.

Mechanical Structure of Pulp.

Examination shows that the reason for the extreme difficulty with hand separation lies in the peculiar physical nature of the mashed pulp. This appears to be composed of, a mixture of fibres and an oily sludge whose consistency varies with the moisture content of the pulp. Between the usual limits for a mashed pulp of 30-40 *per cent.* of moisture, the consistency is that of a thick mud, and it is very soon obvious that the clean separation of this mud from the nuts is impossible without the aid of fairly elaborate apparatus capable of scraping or brushing the nuts. Attention has therefore to be turned to the effect of increases or decreases of moisture content on what may be termed the " muddiness " of this portion of the pulp.

From the pulp analyses given above it will be seen that an average pulp is composed of:—

Oil	about	48.5 *per cent.*
Water	,,	34.0 ,, ,,
' Fibre '	,,	17.5 ,, ,,

The structure of the " fibre " portion is roughly as follows:—

Coarse Fibres	55 *per cent.*
Pulp Tissue	25 ,, ,,
Water-soluble	20 ,, ,,

The coarse fibres are hard and woody and about 1″-2″ long: some 80-100 of these are joined together at the base of the fruit forming a skeleton for the support of the soft, oil-bearing pulp tissue. This latter is composed of large, thin-walled cells, and is broken up during the mashing process into a sludge of ruptured oil cells, oil and water. The completeness of the breaking-down of the pulp cell structure is seen by microscopic examination of a little well-mashed pulp in aqueous suspension: the average size of

the particles of pulp tissue probably amounts to some three or four cells. This process, however, leaves the coarse fibres as well as the epidermis of the fruit more or less intact: to some extent these are broken up individually, but there is little collapse of their cell structure. The mashed pulp therefore consists of a mat of coarse fibres and epidermis interspersed with a sludge of intimately mixed oil, water, and pulp-cell tissue. This (pulp-cell) sludge has the following two important properties:—

(1) As a result of its large surface area per unit weight, it has powerful capillary properties: thus the mashed cells, dry and oil free, are capable of absorbing some 20 times their own weight of water to form a semi-solid sludge. Similar behaviour is shown towards palm oil by the dry cells, but in a mixture of oil and water, water is always preferentially absorbed.

(2) The sludge of mashed cells is "*per se*" incapable of direct press extraction, on account of its very small particle size, but requires a filter-pressing process. In the normal way a very satisfactory filtering medium is provided by the mat of coarse fibres (and epidermis), and direct press extraction of the whole pulp is possible. But the retaining action of this fibre mat is, for a given pressure, limited to a certain volume of mashed pulp-tissue, and, if this volume be exceeded, a portion of the sludge is expressed unchanged. As has been seen, the effective volume of the pulp-tissue mash is determined very largely by its moisture content, and for any given pressure it is found that there is a limiting pulp moisture content above which some unchanged sludge will be expressed.

Wet Separation. "Soft Oil" Extraction.

When quantities of water greater than are required to saturate it are added to mashed palm fruit pulp, segregation of the constituents in order of specific gravity begins to occur. Thus when a weight of water equal to three times the weight of pulp has been added, with constant stirring, the "pulp-tissue" mash at once goes into uniform suspension in the water, which is now not a sludge, but a viscous liquid: the nuts sink to the bottom: the coarse fibres are suspended, and may be separated by hand or by means of a coarse sieve. As the quantity of water is increased to some six times the weight of pulp, the viscosity of the suspension gradually falls till a point is reached where oil begins to rise to the surface. The conditions are now those of a "soft oil" extraction: the extraction is made by continual agitation of the suspended cells whereby loosely held oil is dislodged and floats to the surface: the extraction force is the preferential capillary attraction of the "pulp tissue" for water aided by the differences in specific gravity of oil and cell

tissue. At the end of the process the coarse fibres are separated by sieving, but the " pulp-tissue " is lost with the water which is useless for further extraction on account of its viscosity.

The distribution of the oil losses in the " soft oil " process has been found to be roughly as follows :—

Loss, % of Total Available Oil.

	Coarse Fibres (surface).	Pulp cells.	Total.
Average	17%	23%	40%
Minimum	15%	20%	35%

This process appears to be limited to an efficiency of 60-65 *per cent.* : the latter is only obtained with considerable effort.

If, therefore, the separation of the pulp from the nuts is to be made by washing with water, it will be necessary to recover the suspended " pulp tissue," unless the process is carried out in conjunction with a " soft oil " extraction, and only the readily recoverable coarse fibres submitted to press extraction. It will be seen that simply by pressing the recovered coarse fibres only a small proportion of the oil losses is recovered : the efficiency may be increased to some 65-70 *per cent.* thereby.

Filter Process.

Recovery of the suspended " pulp tissue " can in fact be effected by a filtration process, suitable media being sacking, coconut matting, or a mat made from the previously separated coarse fibres. Filtration is, however, slow, and, at the end, the problem of filter-pressing the bulky sludge with the aid of the coarse fibres has still to be met. This is fairly simply solved by mixing in the sludge in stages and pressing after each stage : a yield of oil and water is obtained and in this way the sludge is gradually press-dried as it is mixed in.

A process on these lines has been worked for some time using as filters long, shallow trays 12 feet by 2 feet and 6 inches high. The filtering medium was supported by a series of parallel wooden ridges fitted along the bottom of the tray, and the filtrate run off along the grooves between them, which were $\frac{1}{2}$ inch deep by $\frac{1}{4}$ inch wide. Using this process 500 lb. of mashed fruit can be extracted in 5-6 hours by two women as follows :—

Washing and separation of coarse fibres ...	$1\frac{1}{2}$ hours.
Filtration	2 ,,
Mixing in and pressing	$1\frac{1}{2}$,,
Decantation of oil and water, and drying oil	$\frac{1}{2}$-1 ,,

The nuts are left remarkably clean, and the full yield of 80-85 *per cent.* of the available oil is obtained.

Taking into consideration the somewhat complicated treatment necessary for the resulting sludge, it has to be concluded that such a process is hardly likely to be a success in the hands of African farmers. It is, nevertheless, difficult to imagine any practicable process other than one of filtration, which will recover the entire pulp from aqueous suspension, and experiment has shown no way, possible to a small farmer, in which either the rate or completeness of the filtration can be appreciably improved. Wet methods of nut and pulp separation are therefore unsatisfactory in conjunction with press extraction.

Dry Method Separation.

It has been mentioned that the "stickness" or "muddiness" of the pulp, responsible for difficulties in nut separation, bears a noticeable relation to the moisture content. If the pulp is slowly dried there is a gradual loss of these characteristics accompanied by a colour change from light to dark-brown, and the bulk of the "pulp-tissue" portion diminishes relatively to that of the coarse fibres. When the moisture content has fallen from the normal 35 *per cent.* to some 25 *per cent.*, the pulp is found no longer to adhere to the nuts, and the condition for separation is considerably improved. Following a series of experiments on mashed fruit dried to a similar extent a simple and rapid method of separation was found, depending on the difference in the frictional resistances of pulp and nuts to a rough surface. The procedure is as follows:—

> A drying table is prepared from a sheet of six feet by six feet heavy-gauge corrugated iron sheeting (this size has not been found to be commonly obtainable, and must be made by rivetting together two six feet by three feet sheets). The *corrugated* edges are nailed to two wooden beams of about four inches by two inches section: these are protected from burning on their inside faces by a rough covering of old iron roofing or tinplate. A fairly rigid table is thus obtained which may conveniently be supported by four kerosene tins under the corners. It is of advantage to fit two wooden edges some three inches high to the two *straight* sides of the table to prevent loss of fruit when raking.

The fruits, after separation from the bunches, are boiled for three hours in water. They are removed from the boiling vessels, drained in baskets, and mashed while still hot. The warm mashed fruit is at once given a first pressing, care being taken to obtain a yield at this stage of some 50-60 *per cent.* of the available oil as described below ("pressing of whole fruit"). The once-pressed

cake is spread on the drying table, and dried in lots of 100-150 lbs. at a time. A large fire is unnecessary, but it should be spread out: the fruit should be turned occasionally with a rake. Drying is complete as soon as the nuts are seen to be fairly free from adhering pulp, usually after 10-15 minutes. The period of drying is considerably prolonged if the fruit is unripe.

The separation is carried out on a wooden board some six feet by three feet (the size is immaterial) fitted with a two inch-high edge to each of the long sides, and supported at one end so as to slope with the ground at an angle of 30°-40°. The angle of slope required bears an inverse relation to the dryness of the fruit, but there is latitude enough to make adjustment rarely necessary. The dried fruit is plied in successive lots on the high end of the board, and agitated by hand or short strips of wood: the nuts almost free from adhering pulp continue to roll to the bottom until almost nut-free pulp remains on the board. A few chunks of pulp which may roll down also as separation proceeds, are picked out without difficulty. This separation process requires three labourers, two at the top of the board turning the fruit over so as to liberate the nuts, and one at the bottom responsible for any final cleaning up of the nuts. Some 400 lbs. of fruit may be separated in an hour on a six feet by three feet board. The drying process, which requires the attention of one labourer, is carried out simultaneously with separation. The separated pulp is at once, and without re-warming, given a second pressing. A third pressing may be given, but the yield is usually small.

In the table below the labour requirements of an extraction process using this dry method of nut separation are compared with one in which the separation is made by hand:—

Weight of fruit	500 lb.
Number of labourers	4
Capacity of press cage	5 gallons.

METHOD OF NUT SEPARATION.

	Dry Method.	Hand Picking.
a. First Pressing (whole fruit)	1 hr. 30 min.	1 hr. 30 min.
b. Drying and separation on board ...	2 hrs. —	—
c. Hand Picking	—	3 hrs. —
d. Reheating separated pulp	—	— 30 min.
e. Second Pressing (separated pulp) ...	— 30 min.	— 30 min.
Total	4 hrs. 0 min.	5 hrs. 30 min.
Extraction Efficiency Percentage of available oil recovered under 3 cwt. per sq. in.	80–83	75–80

The separation need not be carried to absolute completion, as it is only actually necessary to reduce the proportion of nut below some 40 *per cent.* by weight (*see* paragraph on "nut-pore-space"), and such nuts as may be left in the residual pulp tend on the whole to be the smallest, and therefore least valuable. A nut recovery of 95 *per cent.* is quite easily obtained.

Any objection to this method must lie in the drying process. The purpose of drying is not, however, only to facilitate nut separation: it simultaneously conditions the pulp for the second pressing. If an attempt is made to extract undried pulp in a press, the last 25 *per cent.* or so of the oil yielded will be intimately mixed with the pulp-tissue-water sludge (previously described), from which the oil can only be recovered, without great loss, by a flotation process similar to a "soft-oil" extraction. The behaviour of the coarse fibres as a filtering medium, and the relation between their retaining power and the moisture content of the pulp have been mentioned: it follows that, in order to avoid expulsion of sludge with the oil, palm fruit pulp should always be dried at some stage before final extraction in a press. For several reasons it is of advantage to carry out the drying after a first pressing of the whole fruit, when the re-warming of the pulp preparatory to the second pressing and the drying conveniently take place together. The use of a drying table for this purpose has been found a great improvement on the cumbersome and laborious "Cooker Press" method of stirring in an iron pot, with its ever present risk of local over-heating.

An apparatus for dry-heating the pulp is therefore of great value, if not essential, whatever be the method of nut separation employed. The "dry method" of nut separation just described requires the dry heating of the whole mashed fruit, instead of merely separated pulp, and the extra labour involved in this, though by no means negligible, is small in comparison with the labour of hand-picking.

This process therefore to a great extent eliminates the wearisome hand-picking from the press-extraction process, and, possessing the necessary qualifications of great simplicity and minimum cost of apparatus, can reasonably be suggested to African farmers.

Extent of Drying.

The limit to which drying should be carried, if pressures of three to four cwt. per square inch are to be applied, may be calculated from the analyses of pressed pulps to be some 18 *per cent.* of moisture to the original pulp. Below this, unnecessary loss of oil must be expected as a result of the residual absorptive capacity of the pulp

(under three to four cwt. pressure), not being satisfied as far as possible with water. In practice this figure is scarcely likely to be reached on account of the wastage of labour and fuel required to achieve it.

An arbitrary indication of the degree of drying which will avoid on the one hand, excessive expulsion of sludge and, on the other, undue loss of oil in the pulp, is fortunately supplied by the dry method of nut separation, as the correct moisture content for pressing is approximately that which just allows clean separation.

First Pressing of Whole Fruit.

The desirability of extracting some 75 *per cent.* of the total expected oil yield in a first pressing of the whole fruit has been referred to. Clearly the higher the proportion of the oil which can be obtained at this stage, the less will be the losses of oil on the surface of the nuts, and in any pulp still adhering to them after separation. The proportionate yield of a first pressing depends on the relative volumes of nuts and pulp, and the volume of the latter is determined to a considerable extent by its moisture content. Hence it is important *not* to reduce the moisture content of the pulp before a *first* pressing of the *whole fruit* (of the Nigerian thick-shelled ordinary type). In the case of rich fruit (42-50 *per cent.* of pulp) such a yield wil readily be obtained in a first pressing: it will usually, in fact, be possible to compress the pulp far enough to cause expulsion of sludge, at which stage the pressing should be stopped. In poorer fruit (35-42 *per cent.* pulp), on the other hand, the volume of the pulp in the normal state may not be enough to permit a satisfactory yield at this stage, and it may even be desirable in such cases to increase the volume artificially by *addition* of a little water prior to the first pressing. It will be found that oil only is yielded on pressing the watered fruit on account of the preferential absorbtion of water by the pulp, but the subsequent process of drying will, of course, be slightly prolonged as a result.

Quality of Pressed Oils. F.F.A.

A comprehensive account of the occurrence of fatty acids in extracted oils is given by Barnes (loc. cit.), and it is conclusively shown that the degree of hydrolysis is determined largely by the treatment which the fruit receives between harvesting and boiling, and only to a very minor extent by the nature of the subsequent extraction process.

Undoubtedly the storage of fruits bruised in the falling of the bunch from the tree does result in very rapid increase in the F.F.A., of the oil contained in the bruised portion. The actual proportion of pulp cells so ruptured, however, is normally not very great, and

the authors experience has agreed with Barnes' that storage of unbroken fruits on the bunch for periods up to a week rarely results in more than a slight rise in F.F.A. (about 0.5 *per cent.*). The F.F.A. content of native-made " soft " oils is considered to be dependent in great part on the frequency of harvesting, and the consequent inclusion, or not, of over-ripe fruit. The following experiments made with fruit of varying degrees of ripeness indicate that the degree of breaking down of the cell structure resulting from overripeness is far greater than is likely to result from a single bruising of the bunch :—

Description of Fruit.	F.F.A. of contained oil. (% as Palmitic Acid).
1. Under-ripe. 20 days before full ripening	2·08
2. Under-ripe. 20 days	1·75
3. Under-ripe. 15 days	1·17
4. Just ripe	0·52
5. Just ripe	0·26
6. Just ripe, after 5 days storage	0·66
7. Very ripe	1·10
8. Over-ripe. Slight discolouration at base	6·90
9. Very over-ripe. Pulp softened and some nuts visible ...	28·5

In these tests the fruits were sterilised in boiling water immediately after removal from the bunches: only fruits which were apparently undamaged were used.

Where fruit is scarce and harvesting irregular, more over-ripe bunches will be met with, and less willingness felt to reject them. The rate of increase of F.F.A. in such fruit on storage is of course very great, and must account largely for the more acid " soft " oils, and for the considerable local variations that are found. The rejection of all fruit but such as is just ripe is, however, in practice, impossible, partly because of frequent variations in ripeness of different portions of the same bunch, and partly because of the brevity of the " just ripe " period (two or three days). For this reason bulk extractions of palm fruit, even where there has been a minimum delay between harvesting and sterilising, rarely yield an oil of less than three *per cent.* F.F.A., and more commonly one of five to eight *per cent.*

In comparison with these factors the effect of the extraction process is small, providing that the fruit is at no stage brought into contact with active enzyme. Inasmuch as they lay themselves open to a greater risk of this, the " soft oil " flotation methods might perhaps be considered less reliable than mechanical methods from this point of view, but in practice little appreciable difference is found.

Colour.

Oils prepared for the export market by any method involving dry-heating either of the oil or of the fruit are liable to another and serious fault—a bad or over-dark colour. In the majority of the manufacturing processes for which palm oil is used its colour is a disadvantage, and a bleaching process has to be employed. Brokers' reports on samples of "Cooker-Press" palm oil shipped to England indicate that it is somewhat dark in colour and difficult to bleach: it was reported, on account of its low F.F.A. (six *per cent.*), as suitable for the tin-plating industry. It would obviously be useless to the soap maker if difficult to bleach, and thereby be barred from one of the biggest consumers.

The darkening in colour was traced to carbonisation of some of the water-soluble constituents of the pulp, and was found liable to occur at two stages in the process, the dry-heating of the pulp prior to a second or third pressing, and the drying off (by boiling) of any residual water from the oil. Drying of an aqueous extract of palm fruit pulp was found to result in the formation of a carbonaceous mass, even if the drying was carried out at 100°C., (*e.g.* in a steam-oven). There is therefore some risk of this occurring whenever pulp is dry-heated, but this risk has been considerably minimised in the "dry method" extraction described in this paper. In the first place such oil as is extracted in the first pressing,—before drying—, will not be subject to discolouration from this cause. In the second, the open drying table described is very much less likely to cause local charring of the pulp than the pot heater previously used.

The "drying-off" of the oil yielded by a press amounts to evaporating a certain quantity of a solution of the water-soluble constituents which has been expressed at the same time. By adjusting the dryness of the pulp as has been described, this can be reduced to a very small amount but not to nothing, unless a risk of excessive loss of oil in the press-cake is to be incurred. The result of the drying, even if the temperature of the oil be not allowed to rise above 105°, is a gritty, carbonaceous deposit. The formation of this may be simply prevented by washing the oil with a fair bulk of water before "drying off" and decanting, but it is intended for the present that the inclusion of this process, which entails some extra labour, shall await the results of future work.

It is noticeable that the same causes as are responsible for a darker colour give rise to a flavour in the oil which appears to be appreciated by the Nigerian market.

Apparatus.

(a) *Hand Presses.*

The original Culley-Ducolson steel screw-press, used and described by Barnes, was of the "bridge" type with two side-pillars, and a heavy, girded crosshead. Its cage of $\frac{1}{8}$ inch sheet steel was 12 inches in height by $11\frac{1}{2}$ inches in diameter, and drilled with 1/16 inch perforations: the screw shaft had a two-inch section, and a pitch of three to the inch.

This machine has been found mechanically satisfactory, provided the joint in the cage is rivetted and welded: its cage capacity of nearly five gallons is, however, too small, and its price of £22 very much too high. By a series of minor modifications, a model was eventually offered at £15 in Nigeria, but this is still not a very attractive proposition, and the farmer is unable to understand why he must pay this sum for a small and apparently simply-made press, when a comparatively intricate machine such as a bicycle is obtainable at £8 or less. In this, one's sympathies are with the farmer, even after making allowance for the cheapening effects of mass-production. It has therefore become necessary to look for modifications in design which will cheapen the cost of production.

Experiments were made for some time with machines operated on a lever principle: in these the cage and base-plate of the Culley-type press were retained, and the pressure applied by means of a wooden beam lever whose short end passed under a small iron bridge clamped to the base-plate: it was possible to produce these for about £5 each, but they were cumbersome in operation and lacked the necessary mechanical advantage.

A screw press having a locally made frame of Iroko wood, but with a steel shaft and screw-on bush, was then tried. Its cage was built of circle of wooden laths $\frac{1}{4}$ inch apart, banded with rings of $\frac{1}{8}$ inch steel. It can also be made for about £5, but its framework requires strapping with the same $\frac{1}{8}$ inch steel to withstand the pressure, and, even then, its durability is somewhat doubtful.

A near approach to the solution has more recently been found in some machines made by Messrs. Duchscher & Cie, of Luxembourg. They have a similar wooden-lath cage, but of a total capacity of 22 gallons. The screwed steel shaft, of $3\frac{1}{2}$ inches cross-section, is permanently fixed in the centre of the base-plate, the turning-arms and ram-plate being attached to an internally threaded block free to move on this shaft. The cage has therefore either to be made in two vertical sections, or to be hinged, in order to enable removal of pressed pulp. Crosshead and side pillars are, of course, dispensed

with. The shaft passes through a circular, cast iron tray-base-plate, and is firmly attached to an iron-framework base. The makers are able to sell this press in Nigeria at £13, and are preparing a model of nine gallons capacity for the Nigerian market at about £8.

The design of these presses is an improvement on the "bridge" type in that the pressure is taken solely by the heavy central shaft, and is not transmitted through the framework of the machine. It is also very much more sturdy and obviously more durable than the previous models. It is noticeable that the spacing between the wooden laths of the cage is roughly $\frac{1}{8}$ inch, but this is naturally subject to greater variation than would be the case with a steel cage, in places being as much as 3/16 inch. This again indicates the filtering action of the coarse fibres, and how little need, as a result, there is for the fine 1/16 inch drilled holes of the Culley presses, which are, in fact, quite incapable of restraining the expulsion of sludge, if the pulp under compression is too wet.

(b) *Boiling and Mashing.*

Little practical objection has been found to the usual native method of softening the fruit by boiling in water prior to mashing except on the score of the fragility and poor heat qualities of the pots: such advantages as a steaming process has over this have hardly seemed to justify the more elaborate apparatus necessary. A sheet-iron pot made by cutting transversely used tar—or bitumen-drums (which are at present available in considerable quantities) has been found a very suitable substitute for the native earthenware pots, more especially as it is equally suitable for replacing the wooden native mortars in which the mashing is carried out. It has an effective capacity of 35 gallons, or about 150 lb. of fruit, and costs 1s. or 1s. and 6d.

(c) *Drying Table.*

It was felt that these tables should preferably be made locally and therefore from readily obtainable materials. From this point of view there is scarcely any alternative to the use of corrugated iron sheeting. As commonly obtainable in Nigeria for roofing, however, the heaviest gauge is 1/24th of an inch, and this has not quite the necessary rigidity. It is desirable, in making the tables from this, to rivet two six feet by three feet sheets together, as has been described, and increase the rigidity by means of a third sheet placed centrally under these. The total cost of the table is about 12s.

Such tables still leave a certain amount to be desired, and the possibility of importing specially made tables at about the same price is being investigated.

Total Cost of Apparatus.

It is intended that both nine-gallon and 22-gallon presses should be available for farmers according to the scale of the work required of them. The apparatus which will be necessary in conjunction with these will then be :—

a (capable of extracting with ease 800 lbs. of fruit a day)

	£	s	d.
1 9-gallon press	8	0	0
1 drying table, say		15	0
1 separating board, six feet by three feet ...		5	0
6 boiling and mashing drums		9	0
Total	9	9	0

or *b* (capable of extracting 1,000 lbs. of fruit a day)

	£	s	d.
1 22-gallon press	13	0	0
2 drying tables, say	1	10	0
2 separating boards		10	0
12 drums		18	0
Total	15	18	0

Review.

In the use of the simple apparatus in the process described in this paper, the more important characteristics of native industries are retained as far as is possibly consistent with the improvement of efficiency. The capital outlay is not great, and the machinery is of a heavy type which depreciates very slowly, and can be " laid up " if necessary without serious loss.

In the future, should there arise a real demand for larger scale, power-operated extraction plant, the authors are in complete agreement with Barnes that from every point of view this must be of the centrifugal type It is, in fact, only on account of the more elaborate and costly nature of the machinery that centrifugal methods are not suggested for small-scale work.

Acknowledgments.

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For Tables see pp. 220-223

SOME COCOA SOILS OF THE EASTERN PLAINS IN NIGERIA.

By M. GREENWOOD, M.SC.

Introduction.

Attention has already been directed to the poverty of the soils of the Eastern Provinces, and to the difficulty of providing the farmer with an exportable crop. In discussing the results of trials of kola, coffee and cocoa, of which only the first two show promise, at the experiments stations in Benin and Umuahia, the Director of Agriculture (1) says :—

"The result of repeated efforts shows that cocoa is not sufficiently hardy to be established except on land that is fairly thoroughly cleared, and kept free from weeds and regrowth of bush for two or three years by growing other crops between the cocoa. But it is also evident that the soils at these farms are just on the border-line between the soils on which cocoa will grow and those on which it will not. At some points on the farms cocoa has been established and is doing fairly well, while only a few yards away continual and repeated efforts have failed. Observations and enquiries on the few old native farms that exist on this type of soil confirm these deductions from our own experience and also suggest that, on the poorer grade of this soil, at least, cocoa even when satisfactorily established will be liable after some years to die out, without suffering from any apparent disease."

The data here presented are the result of an examination of areas where it has proved difficult to establish cocoa—as land withdrawn from cocoa on native farms had usually been planted with another crop, observations were confined to the experiment stations—and of established farms in which there is a varying incidence of die-back. Through the courtesy of the owners the following plantations were inspected in January and February, 1930 :—

The old Provincial Garden and the farms of Messrs. Lawane Bakani and Bakare Obasove, Benin City: Chief Benstowe's farms at Ikorodobongo and Azumini, and the farms of Chief Okon Etim Udo and Mr. Okon Etim Nita at Otokpo, Itu, on the Cross River.

The best trees on these plantations were so disappointingly poor that comparative observations were made in April at Arun, Olode and Ikija, some of the best cocoa-growing areas in the Ibadan district.

Condition of Trees.

The great variation in plantation practice from one farm to another makes some account of their history necessary.

Ogba Experimental Farm, Benin.

Three blocks, S, F and H, are under cocoa at the present time; other blocks have been abandoned to kola. Of the three, block S is the biggest and most interesting.

Thirteen half-acre plots are used in a trial of palms and cocoa *versus* cocoa alone and palms alone. Cocoa (12′ by 12′) is interplanted with oil-palms (36′ by 36′) on the odd plots, cocoa alone on plots 2, 6 and 10, and palms alone on plots 4, 8 and 12.

Cocoa was planted at stake in 1924. The bush was cut but not stumped, and the seed placed in planting holes, 3′ deep and 2′ diameter, which had been dug along 12′ rides, and filled with surface soil from bush. Temporary shade was provided by a shelter of palm-leaves, and the rides were ring-weeded. Plantains were put in as temporary shade in 1927, when the plots were cleared. Ridging and the planting of a cover have been carried out only recently.

In general the growth of the cocoa was so spindly that it furnished no ground shade. In most places plantains (some bananas) had made such poor growth that the temporary shade was ineffective, whilst the cover-crop, *Centrosema*, was barely established along 12′ ridges. As a result the soil was highly exposed

There was a great difference in growth on the various plots. Most of the trees on plots 1-7 had shed their leaves, and numbers of branches had dried out, whilst plantain growth was so poor that large areas of soil were completely bare. On plot 9, further down the slope, there was good growth of plantains, and at the east side of the plot there were a few cocoa trees of better shape which had retained most of their leaves and were even fruiting. Plots 10 and 11 were in similar condition, but the growth of cocoa on plot 13, where plantain growth was still good, was again poor. It seemed likely that an old drain passing from E. to W. at the top of plot 9 might have been responsible for these differences. Immediately below this drain were one or two very good trees, but on the west side (the lower level) of the plots trees were in no better condition than on plots 1-7.

Block F, on which a manurial trial on old cocoa land is being carried out (*cf.* table III), was replanted in 1928. Planting holes 3′ deep and 2′ diameter were used; the original soil was replaced in the case of the controls, and the top 18″ mixed with the fertilizers in the case of the treatments. This experiment will be discussed later.

Umudike Experiment Farm, Umuahia.

Plots 41-50 of block J form an experiment in which the cocoa on odd plots is intercropped with mucuna and koko-yams, on even plots with mucuna only. The trees receive an earth mulch after the crops have been removed at the end of the rains. Trees of the same age as those of block S, Ogba, were in rather worse condition. There were one or two good patches, but most of the trees were badly dried out and covered with termites. Growth of bananas was poor and their shade negligible. The block slopes steeply and as mucuna had proved difficult to establish, there must have been an appreciable amount of wash in the past.

On block C, where the soil is much more sandy than on block J, young cocoa is growing with a certain promise. It is very noticeable that the trees on the east side are much better than those on the west.

Native Farms, Benin.

Trees on Bakani's farm were planted about 10′ apart either as seedlings or at stake in 1917. No preparation of a planting-hole was made except for a slight hoeing round the spot to be planted. Palm-leaves followed by plantains were used as temporary shade. Part of the plantation was interplanted in 1920 with para rubber, which has made such excellent growth that parts of the farm are under heavy shade, whilst others are comparatively exposed. Trees first began to die back at the beginning of the dry season of 1928, the general symptoms being similar to those found at Ogba. The condition appeared far less acute under shade. Spreading trees were, however, yielding well in the open, dying trees being invariably of spindly habit. At this stage of the trees' history it is not easy to say whether their inability to supply their own ground shade is a result or the cause of their poor growth.

Similar conditions obtained on Obasoye's farm, where the trees were 16 years old. Kola, which had been introduced at places where the cocoa had died out, had grown very well, and provided parts of the plantation with heavy shade.

Azumini Farms.

Oil-palms provide permanent shade on both of Chief Benstowe's farms, in which the cocoa is from 11 to 15 years old. On the Azumini farm most of the trees are dying back : they are planted about 9′ apart, and are actually touched by the palms. On the Ikorodobongo farm, where the spacing is about 10′, many trees are bearing well, and die-back has been acute only in the last two years. Both farms were heavily covered with weeds at the time of examination.

Cross River.

Cocoa is grown on the alluvial flats of the Cross River under rather unusual circumstances. The plantations are submerged from September to November, and high-water level is indicated by a well-marked line about 2′ 10″ up the tree trunks.

Trees were planted in 1911 under high natural permanent shade, plantains and koko-yams were interplanted when the cocoa was a year old. The soil appeared remarkably fertile and it is regrettable that under ideal conditions for wide spacing the trees should never have been thinned from the original spacing of 6′ by 6′. The result is ludicrous: in some places the trees have made such peculiarly spindly growth that the first branch is 10′ or more from the ground. Yields from the plantations had been fairly good until 1929, when die-back first made its appearance on the receding of the river in November.

It remains to add that except for leaves there is no return of plant food to the trees on native farms: pods are usually buried in pits dug off the plantation, but wood ashes are sometimes applied round seedlings. Nor is there any evidence of cultivation; the cutting down of weeds and mulching during the dry season are apparently not practised.

Soil Type.

Except for a humic discolouration and a reduction of the clay contents of the surface layer no change in soil profile was remarked on any of the Eastern farms down to a depth (7-8′) which the cocoa roots were likely to reach. The percentage of gravel and stones (particles over 2 m.m. diameter) was appreciable in only one sample (No. 76) taken from low-lying bush at Umudike. The absence of stones and the slight change in mineral content at different depths contrast very sharply with the Ibadan soils, where a gravel subsoil was usually met within the first foot and rotten rock encountered within the third or fourth foot.

After removal of organic matter, all the Benin surface soils, chocolate to black, gave the bright terra cotta colour which characterised the subsoils. It will be seen from the mechanical analyses that two fractions, coarse sand (mainly quartz crystals) and clay, predominate: the comparative absence of intermediate fractions gives the wet soil a peculiar gritty feel. These soils are typical of the deep earths associated with the "Benin Sand Series," which extends over a large part of the southern half of the country. A marine deposit, allotted by Wilson and Bain (2) to the Pleistocene period, this formation is the youngest in the country. Meridionally

running ridges of sands, clays and conglomerates, up to 300′ in height, are the chief physical feature of the Benin district. The tendency for the clay to occur as pellets, a characteristic of the soils, has been noted by the above authors.

The Umudike soils contain a greater percentage of fine sand. There are marked differences in colour and texture between the two blocks. Block C is a coarse soil, natural colour reddish brown, whilst block J consists of a greyish surface soil overlaying a stiff yellow clay. Wilson and Bain describe similar clays found in the immediate vicinity in association with the lower lignite series (Eocene) on which the farm stands (2).

On the river side the Cross River plantations had a covering of fine silver sand whilst further inland the surface was covered with a thin layer of clay which had cracked on drying. The underlying yellowish brown soil was largely composed of fine sand, and persisted to seven feet the lowest depth examined.

Field Examination.

Root Systems.

Deep pits with a vertical face touching one side of the tree trunk were dug against a number of good and bad trees on each plantation in order to expose a section of the root system. Interesting results were obtained on the experiment stations, where coarse surface soil from bush had been used to fill the planting-holes.

With the exception of the tap-root, in no case had any root succeeded in passing from the plainly defined dark soil of the planting hole into the surrounding terra cotta soil except within the top 9″. The planting-holes were filled with laterals which, on striking the red soil, had turned spirally within the hole, and in some cases had even turned upwards into the surface layer of the surrounding soil, where they had developed a superficial network of rootlets. In the case of poor trees this superficial system had barely extended beyond the edge of the planting-hole, but from good trees on plot S 10, Ogba, surface roots spread 7′ radially from the trunk.

The change in the tap-root on striking the red soil was no less marked. Immediately on crossing the boundary of the hole it narrowed down from a vigorous root, nearly an inch across, to a straggling cord of about $\frac{1}{8}$″ diameter, which reached a depth of six to seven feet.

Where, in native farms, no preparation of a planting-hole had been made, more normal root systems were encountered. Certain drying trees on Bakani's farm, Benin City, were found to have had

root growth arrested by a curious hardpan formation, which was later identified as part of an old baked mud wall, the ground having been used for building purposes. Root growth was otherwise good, but both good and bad trees on all the plantations had a number of dead roots in which Mr. Laycock, Mychologist to the Department, who kindly examined specimens, was unable to find any specific disease.

Soil Reaction.

Rough determinations of the pH values of different parts of the farms and of profiles of individual good and bad trees were made, using strips of waxed paper and indicator solutions.

On the experiment stations no consistent differences in reaction between profiles of good and bad trees were obtained. The following values, redetermined by the quinhydrone electrode, are typical.

Dying Tree Plot S2, Ogba.			Good Tree Plot S10, Ogba.		
No.	*Description.*	*pH.*	*No.*	*Description.*	*pH.*
41.	Top 9″ outside planting-hole ...	4·7	49.	Top 9″ outside planting-hole ...	4·7
42.	Top 9″ inside planting-hole	4·8	51.	Top 9″ inside planting-hole	4·7
44.	At 2′ 10″ outside planting-hole ...	4·8	50.	At 2′ 6″ outside planting-hole ...	4·6
43.	At 2′ 10″ inside planting-hole ...	4·6	52.	At 2′ 6″ inside planting-hole ...	4·8
4145.	From 4′ to 7′	4·6	53.	From 4′ to 7′	4·6

Variation in reaction from farm to farm was, however, considerable, and the experiment stations were found more highly acid than any of the farms on which cocoa had been established. Differences between the various parts of native farms was greater than in the case of the stations, but erratic with one or two notable exceptions. Thus the best tree on Bakani's farm was growing against the house, where it received all the family refuse. The surface soil around this tree had a reaction of pH 6.0 as against a rough average of 5.6 for the rest of the farm, and the soil around the better trees on the Cross River plantations appeared less acid than the average. (*cf.* soils 83-86).

Laboratory Examination.

A composite sample of soil from different depths was obtained from the four worst and the four best trees on each plantation; four cores were taken from each tree at point 4′ from the trunk and equally spaced round it. Samples from individual profiles were also air-dried and stored for examination.

Lumps were broken down by a wooden pestle, and the air-dry soils passed through a 2 m.m. sieve. Stones and gravel were expressed on an air-dry basis to include the percentage of moisture on the 2 m.m. portion of the soil.

1. Mechanical Analysis.

The international method (5) was used, but results are here expressed on an air-dry basis to include the percentage of moisture in the air-dry soil (Revised British Official Method ibid).

In the preliminary oxidation only the Ibadan soils, which decomposed hydrogen peroxide catalytically, required the addition of the prescribed quantity of this reagent. Provided that stirring was vigorous and continuous, when the nascent oxygen would appear to take part in the oxidation, there was no difficulty in obtaining satisfactory breakdown of the organic matter in these soils. In the case of other soils half quantities of peroxide were usually found sufficient to effect oxidation.

The silt clay and clay fractions were determined by the pipette method; settling-times were corrected for temperature from data published by Crowther (6). A mechanical end-over-end shaker was used for dispersion, 16 hours being found sufficient.

The " difference " column (table II col. viii), obtained by substracting the sum of the measured fractions from 100.0, is compounded of experimental error and of loss on oxidation. It will be seen that for surface soils the value is generally positive, and roughly proportional to the humic content of the soil. But in the case of subsoils, with a low percentage of humus and a high clay-content, its value is negative. This would appear to be due to absorption of ammonia by the highly unsaturated clays, which gives to the clay fraction too high a value, a result already recorded by Puri (7). The Cross River soils (83-86), which give high losses on solution, yield anomalous results, the " difference " being negative for the surface soils, and positive for the subsoils.

2. " Single Value " Constants.

Coutts (8) has extended the Keen-Raczkowski box experiment (9) to the study of the 1 m.m. portion of the soil, and has shown the value of the data obtained as an index of soil texture. In order to obtain results directly comparable with fractions as measured on the international (Atterberg) scale, determinations of pore space (p) and equilibrium moisture content (w) were made on 2 m.m. soils. The soils were twice rubbed gently through a 100-mesh sieve and the fractions remixed : measurements were made before the publication of Coutts' latest technique (10), so that the older method, using a collared cylindrical box, 2″ diameter and 1″ high, was employed. Fairly good agreement between duplicate determinations of the above values was obtained but slight inequalities in the surface of

the box after shaving off the wet soil were sufficient to destroy the value of measurements of the change in volume on swelling (v), which was small for the coarser soils under investigation.

It will be seen that for soils of this type the constants w and p give very good indication of the clay and humus contents, but comparisons with the results obtained from the Ibadan and the Cross River types of soil suggest that the magnitude of the factors is also influenced by the silt fraction.

3. Reaction.

The Ibadan soils contain large numbers of ironstone concretions, of which the material over 2 m.m. diameter is very often largely composed. The writer's colleague, Mr. C. H. Wright, had found manganese dioxide in similar soils at Ilugun, and their catalytic decomposition of hydrogen peroxide has already been remarked. Heintze and Crowther (11) have examined a number of manganiferous soils which gave anomalous results when their pH was determined by the quinhydrone electrode, although the potential drift usually encountered with such soils was not observed. They suggest the measurement of exchange reaction of N KCl suspensions and solutions as a test for the applicability of the quinhydrone method to a soil; where manganese dioxide is present the suspension gives a higher pH value, owing to the production of manganous hydroxide by the interaction of MnO_2 and hydroquinone.

Ten gr. duplicates of a series of soils were shaken with 25 c.c. Normal KCl solution and allowed to stand overnight. The supernatant liquid was pipetted off from one set of parallels, and the others were shaken up with quinhydrone for 30 seconds and the immediate reaction measured by placing the electrode in the suspension; the pH of the solutions was measured similarly. The results are given in Table I. It will be seen that no appreciable differences were found with the Eastern soils, but that the quinhydrone method cannot be applied to the Ibadan soils.

The reaction of these soils was measured on 1/5 aqueous centrifugates by the Hellige comparator (indicator bromthymol blue). The quinhydrone method was used for all the other soils. Ten gr. soil were shaken for one minute with 25 c.c. distilled water, excess quinhydrone added, shaken for ten seconds, and the reaction measured after 60 seconds. A saturated calomel half-cell was used, and the combination standardized at intervals of 0.5 pH from pH 4.0 to pH 7.0 by means of McIlvaine's buffer solutions (12).

4. Total Carbon and Nitrogen.

Total carbon was determined on the finely powdered soil by combustion in a 3-unit electric furnace; carbonates were not present in the soils under examination, so that total carbon is taken as organic carbon. Nitrogen was determined by the Kjeldahl method.

5. Hydrochloric Acid Soluble P_2O_5 and CaO.

The A.E.A. method was used. 20 gr. finely powdered soil were digested with 70 c.c. concentrated HCl for 48 hours. The extract was filtered and made up to 250 c.c. Calcium and phosphate were determined on separate quantities of 50 c.c. After neutralising with ammonia, calcium was precipitated as oxalate in the presence of acetic acid and determined by titration with N/100 permanganate. Phosphate was extracted from the ignited aliquot by 50 c.c. ten *per cent.* sulphuric acid, precipitated as ammonium phosphomolybdate and determined volumetrically.

6. Lime Requirement.

Measurements of lime requirement as percentage $CaCO_3$ were made by the method of Hardy and Lewis (13).

Ten gr. soil were shaken with 40 c.c. neutral calcium chloride solution, 0.2M, and allowed to stand overnight. Excess quinhydrone was added, and the exchange acidity of the suspension measured. Successive portions of 5 c.c. 0.03N lime water were added, with an interval of three minutes shaking between each addition, until neutrality was just passed. The exact quantity of lime water needed to bring the reaction to pH 7.0 was determined by interpolation.

The exchange acidities in 0.2M calcium chloride are quoted; they were found identical with the values obtained in M KCl for the few soils which were examined in both solutions.

7. Citric soluble P_2O_5

Twenty-five gr. soil were shaken with 250 c.c. two *per cent.* citric acid and heated on the water-bath at 65°C for two hours, shaking at intervals of five minutes. After being allowed to stand overnight, the extract was filtered, evaporated down and ignited with magnesium nitrate solution. Phosphate was extracted from the ignited mass by boiling with 10 c.c. concentrated nitric acid for five minutes, diluting immediately and filtering. Three gr. ammonium nitrate were added and the solution warmed to 65°C 15 c.c. ammonium molybate solution were added and the mixture kept at

65° for two hours. After standing at room temperature for two hours, the precipitate of ammonium phosphomolybdate was filtered off and determined volumetrically.

8. Exchangeable Calcium and Potash.

The method due to Rice Williams (14) was adopted. 25 gr. soil were stirred with 200 c.c. 0.5N acetic acid and allowed to stand for two hours with periodic shaking. The liquid was poured through a filter and the soil leached on the funnel with the semi-normal acid, 50 c.c. at a time until a litre of leachate has been collected.

Calcium was determined on 250 c.c. of the leachate by adding three c.c. 0.88 ammonia solution and five gr. ammonium chloride and precipitating by excess ammonium oxalate from boiling solution. After standing overnight, the precipitate of calcium oxalate was filtered, washed dissolved in dilute H_2SO_4 and estimated by N/100 permanganate.

The remainder of the extract was evaporated to dryness after adding a little hydrochloric acid, ignited, and extracted with boiling water. Using the Milne cobaltinitrite method (15) amazingly low values for exchangeable potassium were obtained. The highest figure was given by soil 85, exchangeable $K_2O = 0.0013$ *per cent.* In most cases the titration figure with N/20 $KMnO_4$ was too near the blank determination on the reagents used (1.00 c.c. N/20 $KMnO_4$) to have any significance. Using a citric acid extract of 25 gr. of soil comparable results were obtained. Soil 85 again gave the highest value for "available" potassium, $K_2O = 0.0072$ *per cent.*, other values having no great significance. It is hoped to repeat these determinations on larger quantities of soil using different analytical methods. The results would appear to have little bearing on the present problem as the Ibadan soils also gave low values.

Discussion.

Soil Texture and Shade.

Amongst soils of similar type the coarser soil appears to promote better growth. The cocoa on block J, Umudike, is markedly inferior to that growing on the coarser soil of block C, whilst on this block the trees on the coarser (east) side (soils 95 and 96) are in far better condition than on the west side (soils 97 and 98). Established farms in Benin and Azumini are again on coarser soil than Ogba or block J, Umudike, whilst it has been seen that in the extreme case the reluctance of the roots to penetrate the heavier type of soil has given rise to a peculiar superficial root system where planting-holes have been used.

Good cocoa with a superficial root system is not rare: according to van Hall (4) trees grown on the stiff clays of Surinam are of this type; there the tap-root dies once the tree is established. But on the plots under consideration there is a definite dry season of about three months' duration and the provision of shade is negligible. Rapid drying out of the surface soil, when the tree is dependent on the atenuated tap-root for its water-supply, would impose a severe strain on the tree and might account for the defoliation which occurs soon after the beginning of the dry season. Heavy mulching with leafy branches has, however, been tried at Umudike for two successive years, and whilst the improvement in plantain growth was most striking, treated cocoa trees appeared to shed their leaves and die out at the same rate as the controls.

To account for the formation of the distorted root system purely on the grounds of texture one would have to postulate a high water table during the rains, with free movement of water only in the coarser soil of the surface layer and planting-holes. The steep slope of the plots at Ogba and Umudike renders this assumption very improbable, and on the lower lying native farms no evidence of water-logging could be obtained.

Nutrient Supply.

It is generally held that cocoa demands a soil rich in calcium. It will be seen that the percentage of exchangeable calcium is very low in the acid soils of the Eastern farms, and that it is lowest on the two plots, Umudike J and Ogba, where attempts to establish cocoa have been least successful. The difference between these soils (e.g. soil 65 Ex. CaO = 0.030 *per cent.*) and the good Ibadan soils (e.g. soil 141 Ex. CaO = 0.308 *per cent.*) is most striking. Native farms on which cocoa has been established and is now dying back occupy an intermediate position.

Pierre (3) has recently examined the factors affecting plant growth on acid soils, and has shown that determinations of critical hydrogen-ion concentration, " active " aluminium and manganese—the factors presumed to produce toxic effects—are unreliable as a measure of likely injury to plants. He regards the potassium/calcium ratio and the percentage base saturation of the soil as primary factors influencing plant growth. The ratio of exchangeable calcium/clay gives, however, valuable information when applied to soils of similar type, and Turner (16) has found good agreement between this ratio and the yields of sugar-cane on the froghopper-blighted fields of Trinidad.

Considering this ratio for the farms it will be seen that the superiority of the native farms, with their coarser soils, is greatly enhanced. Correlation is not possible as fruit yields, where any, were not available, but the ratio gives a rough estimate of the condition of the trees. That a calcium deficiency retards root growth is well known. It seems likely, therefore, that the ratio of exchangeable calcium to clay is approaching a toxic level in the soil of the planting-holes at Ogba and Umudike, and that this level is actually reached in the heavier surrounding soil. This would account for the peculiar root systems exhibited by both good and bad trees on these plots. It is not obvious from the examination why a few trees should have grown so much better than the rest. The possible effect of the organic matter of the bush soils added to the planting-holes in rendering plant nutrients more available cannot be overlooked, and differences between individual trees may be due to differences in the soils with which the holes were filled.

Measurement of phosphate was mainly confined to determination of total P_2O_5. Extremely low values for HCl sol. P_2O_5 had been recorded for certain soils of the Northern Provinces, and examination aimed at finding whether, assuming that liming would render phosphate available, phosphatic fertilisers are required. A few determinations of "available" phosphate were made: soils 65 (P_2O_5—0·0035 *per cent.*) and 85 (P_2O_5—0·037 *per cent.*) represent extreme values. One can only say that the lower figure is considerably higher than the values obtained for many apparently fertile West African soils examined by Martin and Doyne (17).

The C/N ratios are of interest. McLean (18) has examined a number of British and tropical soils and found no correlation between fertility and C/N ratio: he finds that the ratio is typical of a given area and soil type. The few values here determined for the Eastern soils would suggest that on the same plantation the higher ratio is given by the soil with the greater content of humus. Since these results were obtained, a paper by Hardy, Ackhurst and Griffith (19) has appeared, in which correlation between the C/N ratio of the surface six inches of soil and the productivity of cocoa fields is obtained. In the present case good trees produced many more leaves than bad trees and gave much better ground shade. If decomposition of organic matter were slow, the ratio of carbon to nitrogen would naturally tend to a higher level in the surface soils round the better trees.

Conclusion.

The correction of the acidity of only the surface nine inches of the Eastern soils would call for the application of lime at the rate of from one to three tons per acre. The cost of such treatment would

be prohibitive to the native farmer, and it is doubtful whether he could be persuaded to embark on a liming programme even if it could be shown to produce immediate beneficial results. To assure him on this point is difficult. Van Hall (4) emphasises the lack of success which has attended liming experiments on cocoa suffering from a calcium deficiency, and this is confirmed by our own experience.

Since 1928 a manurial trial has been carried out on cocoa newly planted on abandoned cocoa land on block F, Ogba (Table III). Wood ashes, nitrolim, rock phosphate and various mixtures of the three have been used. Although it will be seen that the percentage of available calcium has been greatly increased, and the exchange acidity brought near to neutrality in the case of treatment 4 and 8, there was no perceptible difference in growth between any of the treatments and the untreated controls. Numbers of the young trees had died and the condition of the survivors appeared precarious. The prospect of growing cocoa successfully on the soils under consideration would, therefore, seem remote.

Acknowledgments.

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ON A METHOD OF CONTROLLED POLLINATION OF CACAO.

By O. J. VOELCKER, M.A.

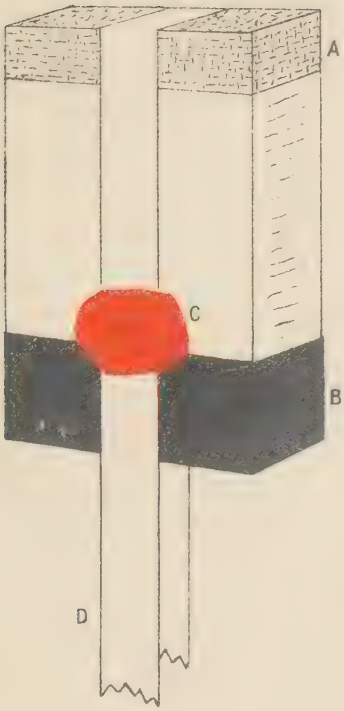
Some difficulty in the technique of controlled pollination of Cacao seems to have been experienced in those countries where interest has been taken in this work. Attempts made to procure self fertilised seed by enclosing the selected tree completely in calico proved unsatisfactory in Java (1) owing to the small amount of seed set, and this method, to say the least of it, is cumbersome and expensive. The usual practice in controlled pollination of bagging the flower before anthesis is impracticable owing to the delicate peduncle and to the small size of the flower itself. To overcome these difficulties a method of controlled pollination has been devised and has proved both cheap and easy of application, having been used with success by the writer in Nigeria over the last nine months.

Essentially the method consists in enclosing the flowers with a box cover, and so preventing the access of outside pollen carried either by insects or wind. The preparation of the box is as follows:—

Fine gauze cloth is gummed over one end of the outer cover of a match box; around the other end an edging of green baize cloth three-quarters of an inch wide is gummed on so that about one-tenth of an inch overlaps the edge of the box. Passing right over the box is a tape which is sealed on to the box on both sides by sealing wax. This tape enables the box to be held firmly in position over the cushion. In order to prevent damage by ants, the tape is previously soaked in solignum. The box and upper portion of the green baize cloth is then varnished to make it waterproof. Each box is numbered for record purposes. Diagram A shows the main features and diagram B the box in position.

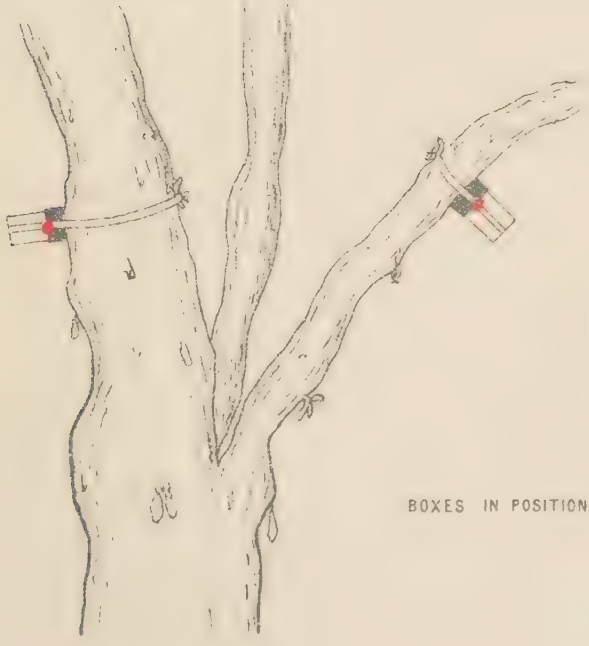
In selecting a cushion from which a flower is to be pollinated preference should be given to one which lies flat on a branch or stem. Any projections, such as dead pod stalks, are cut off flush with the surrounding bark which is scraped clean to remove any moss or lichen growths. Immature buds and open flowers are removed. Round the cushion is now smeared some grease. A satisfactory compound has been made by mixing together in a melted condition eight parts of vaseline, six of beeswax and one of paradichlorobenzene. This grease is also lightly applied to the overlapping portion of the green baize cloth. The box can now be placed over the cushion, and the tape tied round the stem or branch. The serviceable life of a box in daily use is about three weeks.

A



A FINE GAUZE CLOTH
B GREEN BAIZE
C SEALING WAX
D TAPE

B



BOXES IN POSITION

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In self pollination up to three buds can be enclosed by the same box, but it is generally more convenient not to enclose more than two. Out of fifty-nine control flowers which were not pollinated, fifty-seven had fallen before the third day and two before the fourth. Four hundred and thirty-nine flowers have been self pollinated since March, 1931, and the results have been completely satisfactory.

Pending further information on the self pollination of cacao flowers which will be published later, it may be of interest to mention the actual method of self pollination now being used in Nigeria. In the pollination experiments carried out by Stahel (2) pollen was collected from open flowers and applied to the stigma by a feather, but this method has certain disadvantages, chiefly owing to the scanty amount of pollen produced by each flower. It has been found in Nigeria that equally satisfactory results can be obtained by the direct application of a stamen to the stigma, provided this is done during the morning of the first day after anthesis. The stamen is nipped off and gently removed from the petaloid hood with a pair of fine forceps, the whole operation being done in the same movement. A second stamen is generally applied to the stigma to ensure an ample supply of pollen.

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THE ISHAN COTTON PLANT UNDER MIXED CULTIVATION—III.

By E. H. G. SMITH, M.A.

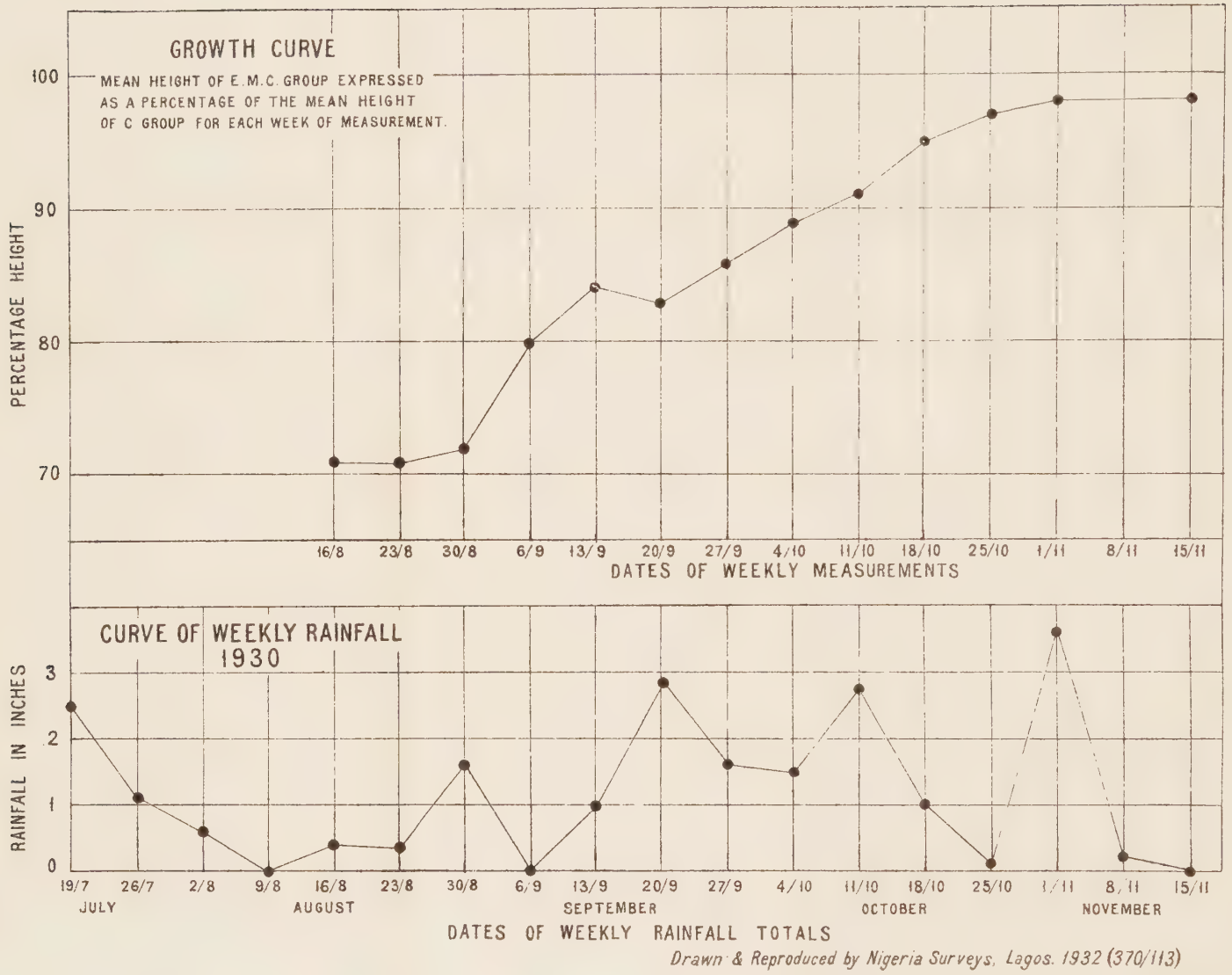
In previous papers, (1) and (2), an account is given of two investigations into the effects of intercropping with yams upon the Ishan cotton plant. During the past season Ishan cotton has been intercropped with early maize and the results of this experiment are recorded in the present paper. In an appendix, a description is given of the study of an observation plot in which Ishan cotton was interplanted with late maize. A large proportion of the cotton grown in the Southern Provinces is intercropped with early maize (1). Early maize is sown towards the end of March and is harvested towards the end of July or early in August. Cotton is sown early in July; thus the period during which the two crops are growing in competition is rather less than one month.

Design of the Experiment.

The experiment was laid out on a similar plan to that adopted for the yam and cotton investigations, (1) and (2), with the exception that a non-experimental border of three ridges was left between all plots. On account of the very heavy shade formed by a crop of maize, these non-experimental borders were deemed advisable to ensure that the intercropped cotton was subject to a similar shade effect as would be experienced on a field scale; also, to guard against the cotton growing alone suffering a heavy shading effect from the adjacent intercropped plots. The experiment consisted of two treatments, cotton alone, denoted as C, and cotton through early maize, denoted as E.M.C. Each plot was composed of three six foot ridges, seventy-six feet long. There were six plots of treatment C and five plots of treatment E.M.C. Of the three non-experimental border ridges between all plots, one ridge, adjacent to each C plot, received treatment C, and the remaining two ridges, adjacent to each E.M.C. plot, received treatment E.M.C. The maize was sown throughout the block on March 30th, 1930, with the stands 18 inches apart on both sides of the ridge, the normal plantation spacing. The maize growing in the treatment C plots, and on the non-experimental C border ridges, was uprooted on July 2nd. The cotton was sown on July 5th, for treatment C plots and border ridges, stands staggered three feet apart on both sides of the ridge; for treatment E.M.C. plots and border ridges, stands staggered between the maize plants approximately three feet

GROWTH OF THE MAIN AXIS

FIGURE 1


GROWTH CURVE
MEAN HEIGHT OF E.M.C. GROUP EXPRESSED AS A PERCENTAGE OF THE MEAN HEIGHT OF C GROUP FOR EACH WEEK OF MEASUREMENT.
PERCENTAGE HEIGHT
100
90
80
70
16/8 23/8 30/8 6/9 13/9 20/9 27/9 4/10 11/10 18/10 25/10 1/11 8/11 15/11
DATES OF WEEKLY MEASUREMENTS
CURVE OF WEEKLY RAINFALL 1930
RAINFALL IN INCHES
3
2
1
0
19/7 26/7 2/8 9/8 16/8 23/8 30/8 6/9 13/9 20/9 27/9 4/10 11/10 18/10 25/10 1/11 8/11 15/11
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DATES OF WEEKLY RAINFALL TOTALS

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apart on both sides of the ridge. The maize growing in the E.M.C. treatment plots, and on the non-experimental E.M.C. border ridges was harvested on July 28th. The maize plants were then uprooted and laid in the furrows. The cotton harvest was completed on March 21st, 1931, and the experiment then terminated.

Observations.

Observations were made as follows:—

(I) Stem heights were measured weekly for certain plants in the middle rows of each C and E.M.C. plot.

(II) Flowers were counted daily for the middle rows of all plots.

(III) The bolls produced on the middle rows of all plots were counted at the weekly harvests.

(IV) The weight of seed cotton was recorded separately for all experimental rows at each harvest.

(V) The maize yields were recorded for the E.M.C. plots.

(VI) Certain observations were made on the incidence of cotton diseases and pests.

(VII) Rainfall was recorded daily.

Results of the Observations.

The results of the observations are now recorded.

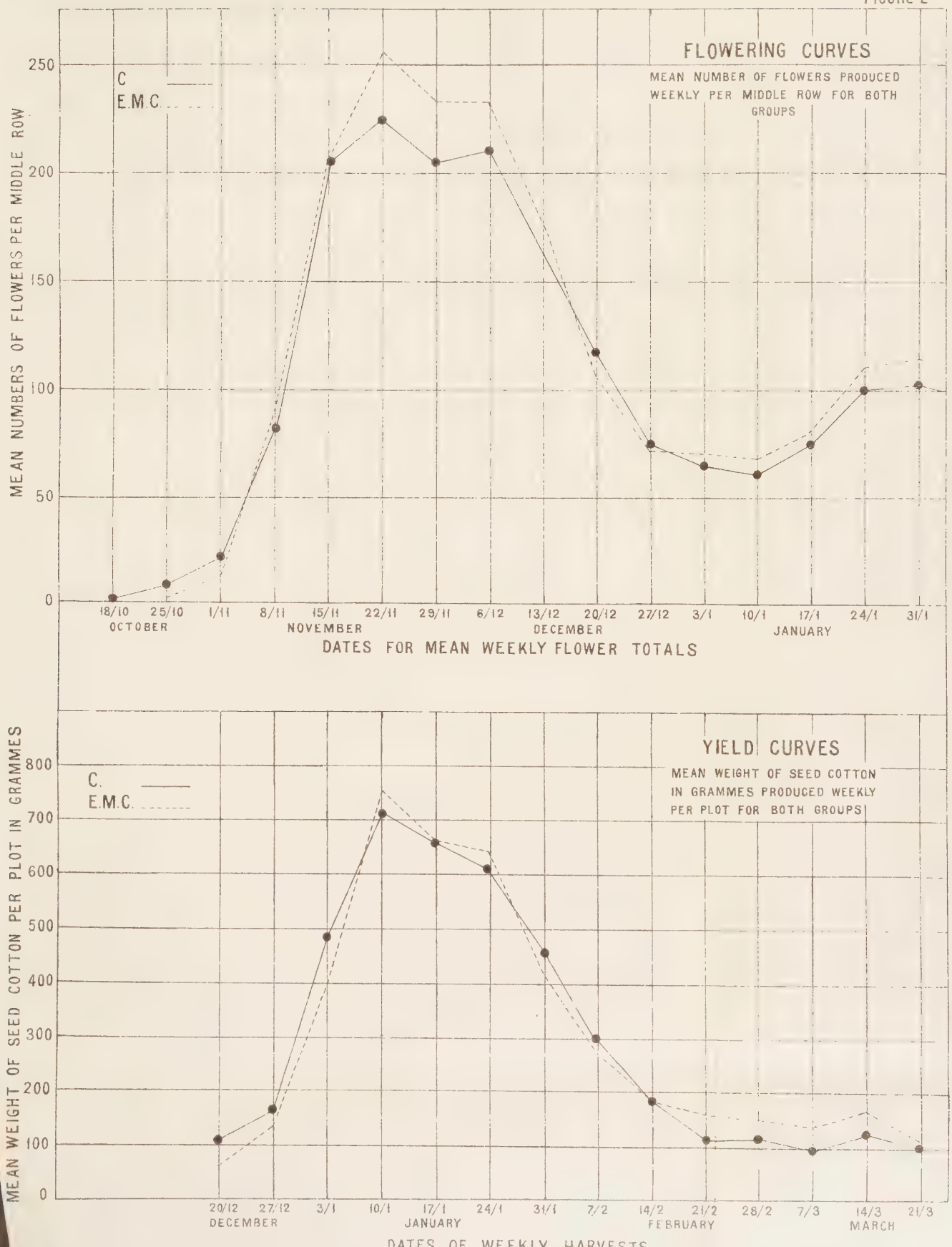
(*a*) *Growth of the Main Axis.*—The method adopted for stem height measurements was described in the original paper of this series (1). The measurements commenced on August 16th and were continued at weekly intervals until November 22nd. By this date approximately one-third of the measured plants of each treatment had been lost on account of damage to, or the abortion of, the terminal bud. In the upper half of figure I is plotted the mean height of the E.M.C. group, expressed as a percentage of the mean height of the C group, for each week. In the lower half of this figure the weekly rainfall is shown. Referring also to figure I of the second paper (2), it is seen that the stem height of cotton intercropped with both early maize and yams is at one time retarded by approximately thirty *per cent.* Thereafter the similarity ends, for cotton through early maize has recovered to nearly ninety *per cent.* of the height of cotton grown as a sole crop by the end of September, and to ninety-eight *per cent.* of the height of C, the limit of recovery, by the end of October. Whereas cotton through yams has only attained to between seventy and eighty *per cent.* of the height of C by the end of September, and to between eighty and eighty-five *per*

cent. of the height of C by the end of October. Thus the stem height of cotton, intercropped with early maize, recovers much more rapidly and much earlier in the season than does the stem height of cotton intercropped with yams. With the exception of the week ending September 20th, the mean weekly increments of E.M.C. were in excess of the mean weekly increments of C from the commencement of measurments up to the end of October, when senescense had almost intervened. Thus with this exception it may be said that, throughout the period of measurements, the E.M.C. group was growing faster than the C group. In the two yam and cotton investigations referred to, C grew faster than YC, in 1928, until the end of October, and in 1929, until the middle of September. Thus the more rapid recovery in the stem height of cotton intercropped with early maize, as opposed to cotton intercropped with yams, is explained. It is not possible from one season's data to determine how far the recovery of the E.M.C. group is influenced by the August rainfall. But it is probable that no rapid recovery in the stem height of the intercropped cotton occurs before the rains recommence.

(*b*) *Flower and Boll Production.*—The flowering curves are given in the upper half of figure II. Both curves show a rather early and very abrupt rise in flowering. The curves agree fairly closely except that during the peak weeks rather more E.M.C. flowers are produced. The only explanation that can be offered for this excess is that, as the C plants were rather more advanced, these at first suffered more severely from the attacks of diseases and pests, with the result that the flowering of the C plants was rather more seriously affected than that of the E.M.C. plants. On account of this difference in flowering, an average of over seven *per cent.* more bolls were produced, and nearly five *per cent.* more bolls were harvested, from the E.M.C. middle rows than from the C middle rows. The percentages of bolls shed to bolls produced were sixty-two and sixty-three *per cent.*, respectively, for the C and for the E.M.C. groups. Thus boll shedding was exceptionally severe for both treatments. Physiological causes were most probably mainly responsible for this heavy boll shedding. The block of land was beginning to show signs of exhaustion as a result of intensive cropping and the spacing adopted was rather close. The 1928 yam and cotton investigation was conducted on poor land and that season boll shedding was severe. The attacks of diseases and pests were undoubtedly a secondary cause of this heavy shedding. As was observed in the two yam and cotton investigations, the percentages of bolls shed are almost identical for both groups, the bolling peaks occur in the same week, and the mean boll weights tend to rise and fall together and to decrease towards the end of the season.

FLOWERING AND YIELD

FIGURE 2



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(*c*) *Yield.*—The yield of seed cotton per row and per plot for both treatments, expressed in decagrammes, together with the maize yields for the E.M.C. plots, as dry grain in lb., are given in table I.

TABLE 1.

YIELDS OF SEED COTTON (IN DECAGRAMMES) FOR C AND E.M.C. (*Plot maize yields, expressed as dry grain in lb., are given in italics*).

C.			E.M.C.		
Rows.	Row Yields.	Plot Yields.	Rows.	Row Yields.	Plot Yields.
2	15·3		8	14·6	
3	17·5	49·3	9	13·2	42·8 (*60*)
4	16·5		10	15·0	
14	16·6		20	15·3	
15	22·0	59·0	21	17·5	53·9 (*61*)
16	20·4		22	21·1	
26	15·8		32	14·9	
27	21·5	5[illegible]·9	33	20·0	46·5 (*59*)
28	17·6		34	11·6	
38	14·1		44	9·5	
39	13·3	40·3	45	14·1	36·5 (*54*)
40	12·9		46	12·9	
50	10·2		56	10·4	
51	8·8	28·5	57	12·7	31·9 (*68*)
52	9·5		58	8·8	
62	6·2				
63	8·6	18·3			
64	3·5				

The experiment gave by far the lowest yield of seed cotton for the season 1930-31 on Moor Plantation. Treated as a single plot the yield was 261 lb. of seed cotton per acre, as opposed to the average yield for the whole plantation, of cotton both intercropped and grown alone, of 407 lb. per acre. The cotton yields fall over the plots of the second half of the experiment and suggest a marked fertility gradient. The yields have been treated statistically by Faulkner's method (3). For this purpose the yields were taken to the nearest point five of a decagramme, and the C plots are regarded as controls for the E.M.C. plots. Analysed in this way the E.M.C. yields show an average difference of - 1 ± 4.8 decagrammes as

compared to the C controls, a difference of no statistical significance. Omitting plots 10 and 11, on account of the low yield of plot 11, the average difference of the E.M.C. yields from the C controls is -3 ± 5.3 decagrammes, this difference is also quite insignificant statistically. Thus it may be concluded that intercropping with early maize is without effect upon the yield of seed cotton. In the lower half of figure II, the mean weekly plot yields of seed cotton are presented graphically for both groups. The two yield curves take the general form of the flowering curves but agree rather more closely. Markedly better average yields are recorded for the middle rows than for the outside rows of the two groups, but in both instances the differences between the means of the two treatments are identical. Thus it cannot be inferred that the observed excess in yield of the C middle rows, over the C outside rows, was due to a border effect of the E.M.C. plots, as the excess of the yield of the middle rows, over the outside rows, is similar for both groups. In contrast to the low yield of seed cotton from this experiment, the early maize gave an average yield at the rate of 1,910 lb. per acre of dry grain. This is a very satisfactory yield for early maize on Moor Plantation.

Incidence of Cotton Disease and Pests.

During the early part of the season, occasional surveys of the incidence of cotton diseases and pests were made. Bacterial disease (*Pseudomonas malvacearum*), (4) and (5), appeared in August and spread rapidly during October. Heavy leaf shedding was occasioned by this disease with some breakage of the stems and branches late in the season. Laycock has pointed out that this disease is usually of not very great economic importance. A few plants were attacked by leaf curl (6). Helopeltis (*Helopeltis bergrothi*) (7) was present in August, increasing numbers of plants were affected during October, and by the last survey, in November, the majority of plants had been attacked. Golding (8) has recently described *H. bergrothi* as the most important pest of cotton in Southern Nigeria. The plants of this experiment were severely affected and the incidence of *H. bergrothi* appears to be increasing. In previous seasons the attacks were observed to be more local in effect and generally less severe than during this year, when all cotton on Moor Plantation suffered. Jassids (*Empoasca facialis*) (8) were present early in the season but migrated to an adjacent plot of beans (*Phaseolus vulgaris*). Cotton stainers (*Dysdercus spp.*) (8) appeared to be rather more prevalent than in recent years. This was also observed at Daudawa (9). No estimation of the casual factors of either the heavy boll shedding or of damage to the bolls was attempted.

Discussion of the Results.

The recent intercropping investigations have been augmented by this study of the effect of interplanting Ishan cotton with early maize. It has been shown that cotton intercropped with early maize suffers a retardation in stem height, which during August is in the neighbourhood of thirty *per cent.* This approaches the magnitude of the basic depression plus the retardation in stem height observed when cotton is interplanted with yams (2). But, whereas cotton intercropped with yams never recovers the basic ten *per cent.* depression, and only recovers slowly and late in the season the variable twenty *per cent.* retardation, cotton intercropped with early maize makes a rapid recovery in growth (probably with the recommencement of the rains after the short dry season). Thus, while in the former instance flower production, and therefore boll production and yield are reduced by from twenty-five to thirty-five *per cent.*, the recovery in growth of cotton interplanted with early maize is so rapid, and is accomplished so early in the season, that flower production, boll production and yield are unaffected. The causes of the low average yields of seed cotton from this particular experiment have been explained. These low yields do not affect the value of the experiment as a measure of the effect of interplanting Ishan cotton with early maize. It has been suggested that the spacing adopted was rather too close; again the conclusions of the experiment are not affected. Reasons have been advanced to account for the heavy boll shedding but no critical analysis of the causes was attempted. The yields of the two treatments have been examined statistically with the result that no significant difference is recorded. Thus it is concluded that interplanting Ishan cotton with early maize is without effect upon the yield of seed cotton.

Summary.

The stem height of Ishan cotton interplanted with early maize is at one time retarded by approaching thirty *per cent.* The recovery in the height of the intercropped cotton occurs both rapidly and comparatively early in the season.

2. It is probable that the rapid recovery in the stem height of the intercropped cotton takes place when the rains recommence, that is at the end of the short dry season.

3. Intercropping with early maize does not affect:—
   (i) Flower production.
   (ii) Boll production and boll shedding.
   (iii) Yield.

4. Bacterial disease (*Pseudomonas malvacearum*) and Helopeltis (*H. bergrothi*) have been shown to be very prevalent on Ishan cotton at Ibadan. It appears that the latter is of some importance but the economic effect of the former is more doubtful.

Acknowledgments.

The writer wishes to record his indebtedness to Messrs. A. V. Gibberd, O. J. Voelcker, J. West and F. D. Golding for their valuable help. The work of the Botanical Assistants is also acknowledged.

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APPENDIX.

The Effect of Intercropping with Late Maize upon Ishan Cotton.

During the same season that the early maize and cotton investigation was carried out, an observation plot was laid down to study the effect of interplanting with late maize upon Ishan cotton. The native farmer only interplants cotton with late maize to a limited extent (1), thus the late maize and cotton investigation was comparatively unimportant economically. When cotton is intercropped with yams or early maize, the cotton is sown through both these crops; but when intercropped with late maize, the cotton is thoroughly established before the maize is sown. Late maize is sown towards the end of August and harvested towards the end of December. Thus the period of competition extends throughout the life of the maize crop. This experiment consisted of only four plots of cotton alone (C) and three plots of cotton intercropped with late maize (L.M.C.). Each plot was composed of three ridges, and three non-experimental ridges were grown between each plot with a similar cropping to that described for the early maize and cotton investigation. The ridges were sixty feet long with twenty cotton stands sown on the tops of the ridges, the stands were three feet apart. On the intercropped ridges the late maize was sown with stands eighteen inches apart on both sides of the ridge. Thus each ridge contained twenty cotton plants, and, in addition, each intercropped ridge contained eighty late maize plants. Similar observations to those described for the early maize and cotton investigation were made. The results are now summarised.

Summary of Results.

(i) Gowth of the Main Axis.—The growth of the main axis of the intercropped cotton was not affected. The mean height of L.M.C. varied from ninety-four to one hundred and one *per cent.* of the mean height of C during the period of measurements. The cotton becomes thoroughly established before the maize is sown, and the competitive effect of the late maize is exerted too late in the cotton growing season for the growth of the intercropped cotton to be influenced.

(ii) Flower Production, Boll Production and Yield.—Flower production, boll production and yield are reduced by from twenty-five to thirty *per cent.* when cotton is interplanted with late maize. With flowering this reduction occurs over the time of maximum flower production; with yield the reduction was more severe during the first half of the harvesting period. The average plot yields of seed cotton for the two treatments, expressed as nominal yields per acre,

were 490 lb. per acre for the cotton alone (C), and 360 lb. per acre for cotton intercropped with late maize (L.M.C.), a reduction of twenty-five *per cent.* The average yield of the four C plots was fifty-five decagrammes and the average difference of the three L.M.C. plots was -11.5 ± 19.6 decagrammes, a difference of no statistical significance. A statistically significant difference was hardly to be expected on account of the design of the experiment.

(iii) Boll Shedding.—As was observed in the early maize and cotton investigation, boll shedding was severe. Fifty-six *per cent.* of the C. bolls, and sixty *per cent.* of the L.M.C. bolls were shed. Thus there is some evidence that boll shedding is slightly affected by intercropping with late maize. There is also evidence that the boll shedding of the L.M.C. group is somewhat heavier than that of C group early in the season and that after the middle of the season the reverse occurs.

(iv) Yield of the Late Maize.—The experiment was not designed to assess the effect of interplanting with cotton upon late maize. But the yields of maize from the interplanted plots suggest that the yield of late maize is affected by intercropping with cotton. Only an average of forty-nine *per cent.* of the late maize stands, established per plot, produced a cob at harvest and many of the cobs were small. The remaining fifty-one *per cent.* of the maize stands had either died before harvest, or failed to produce cobs. The average yield of late maize from the intercropped plots was equivalent to a yield of 745 lb. of dry grain per acre. This is a low yield of late maize for a block of average fertility, such as the one on which this experiment was conducted.

(v) Incidence of Diseases and Pests.—The incidence of cotton diseases and pests was less severe than on the early maize and cotton plot. Bacterial disease was less prevalent, but by the middle of November the attacks of Helopeltis had become general.

BEAN INVESTIGATIONS.

By J. WEST, B.S.A.

Green manuring implies the incorporation within the soil of vegetable matter grown for the purpose. The majority of such crops are legumes. In the broader application of this practice, however, other considerations are recognised. Thus cover crops, besides supplying organic matter and nitrogen, are used either as weed smothers or for the prevention of soil erosion. Such crops may further be cut for forage or utilised for human consumption.

With such a variety of uses, there naturally exists a large number of types suited to particular situations. It follows, therefore, that the first step is in the selection of the most suitable cover crop, after which, methods of treatment can be tried out.

On Moor Plantation, investigations were concerned, primarily, with green manures which would ensure the success of the rotations under trial. In experiments extending over five years, different plants have been compared. Standard crops, such as maize or yams, were used to gauge the annual gain or loss in soil fertility. The smothering of weeds and ease of cultivation were other factors considered. While the results have frequently been statistically insignificant, sufficient data have been accumulated to confirm the cover crop most suited to the plantation practices.

Of the cover crops tried, *Mucuna aterrima* (Bengal bean) has proved most successful. It is a robust climbing bean with long deep purple flowers. The seeds are round and black with a raised white hilum. The pods are short, three to four seeded, black and hairy. The bean is readily established and its vigorous growth makes an efficient smother for weeds. The cover is well maintained throughout the season and is of considerable volume. In one experiment, when maize followed mucuna continuously, the yields of the former were definitely increased. Certain Velvet beans (*M. deeringiana*) such as Georgia, Osceola and Tracey's early black, have also been grown on small observation plots with adequate results.

Dolichos Lablab (Bonavist bean) is a black or brown seeded climbing bean with red-purple flowers and abundant hairy foliage. It is a robust grower and in many respects equals mucuna. Dolichos, however, is not such a good weed smother. In 1926 it was very severely attacked throughout the plantation by *Selerotium rolfsii*, to which fungus mucuna was resistant.

Canavalia ensiformis (Sword Bean) in extended trials has failed to maintain fertility on the plantation. It is not easy to establish and is very inferior to both mucuna and dolichos.

Phaseolus helvolus (Amberique bean), *Calopogonium mucunoides* and *Centrosema plumieri* are at present under trial in a green manuring experiment on the plantation. All three appear to be difficult to establish. Calopogonium is, further, being planted under some of the permanent crops, where it promises to do well.

Recently, more attention has been paid to the question of producing a cover crop which will yield an edible seed. In 1927 selection work was begun by the Botanical section with the Lima beans in use on the plantation and the Popondos sold in the native market. As the result of a yield trial the following year, in which statistically significant differences were obtained, four individual plant selections were retained. During the past season these four strains were used in a time of planting experiment. The results suggested that the optimum planting dates were either immediately following the first rains in March or in late June and early July. It also showed that staking the beans greatly increased both yield and cover, which substantiated experiments carried out on the plantation prior to 1922. Sufficient seed of each strain has been produced to allow field trials to be undertaken by the plantation during the coming season.

The four strains include two Limas, a Rangoon Lima and a Popondo. All are white seeded strong climbing varieties of *Phaseolus lunatus*. The Limas have small flat kidney seeds, mature in about ten weeks and produce a light cover. The Rangoon Lima differs in having small oval seeds. Popondo is a variety of local bean which has large flat kidney seeds, matures in some 14 weeks and produces a substantial cover.

In this selection work, particular attention has been paid to yield, uniformity and seed characters. Some of the white seeded types suffer from what has been termed " black-eye ". After being boiled, a dark discolouration appears round the hilum or eye, although the seeds were originally perfectly healthy. Individual plant selections were successful in eliminating this black-eye in all cases. A yellow discolouration of the seed testa, or " weathering " is still present. In the field, the Limas suffer severely from seed damage due to the larvae of a moth, *Laspeyresia ptychora*,* while Popondo seeds are susceptible to mouldiness. Popondo appears to be highly resistant to chlorosis, a yellow mottling of the leaves, to which the Limas are extremely susceptible.

Note. -This determination was made by Mr. F. D. Golding, Senior Entomologist.

These four botanical bean selections are used as a standard when judging any new types.

Concurrent with this selection work, examples of commercially important bean types were imported from various sources as occasion arose. In 1930 a large collection of local edible beans was obtained through the Superintendents of the out-stations. The plants were grown in observation plots and tested particularly for yield, cover and the edible qualities of the seeds. As far as possible each type has been identified.

Edible types which have been tried out, fall roughly into two groups according as to whether they produce an edible seed alone or combined with good cover. It is unfortunate that, of the commercially important beans so far tested, very few have produced any sort of cover. This applies particularly to varieties of *Phaseolus vulgaris* (Haricot or French bean), *Phaseolus acutifolius* (Tepary bean), *Glycine hispida* (Soy bean) and Wedge pea. Local types which do not produce a cover include *Voandzeia subterranea* (Bambarra groundnut) and *Sphenstylis spp.* A sample of *Phaseolus mungo* (Green gram) from Nyasaland was of this type.

Haricot, Tepary and Soy beans (*see* Appendix I) seem to be unable to establish themselves on the plantation. They yield poorly, die off early and are subject to the attacks of numerous insects and fungi. This may possibly be due to their being temperate climatic plants unable to become acclimatised to tropical conditions.

On the other hand, Lima or Butter beans (*Phaseolus lunatus*) thrive well and produce, frequently, good cover as well as edible seed. Comparisons of estimated yields are apt to prove deceptive. However, in the 1929-30 selection yield trial, the yields of shelled seed per acre were about 400 lbs. for the Limas and about 380 lbs. for Popondo. This implies an increase of 36% and 18% for the Lima and Popondo selections respectively over the 1930-31 plantation yields from unselected seed. The Lima and Popondo selections give, furthermore, a potentially exportable seed. The majority of the local varieties (*see* Appendix III) which have been tried out, have coloured seeds. Since colour sometimes implies the presence of prussic acid, they are of little use for export. A sample of the Madagascar bean did not do well, possibly because it is adapted to particular soil conditions.

Although cowpeas (*Vigna catjang*) are grown by the native to a quite considerable extent, they have not proved successful on the plantation. In green manuring and cover crop experiments extending over five years, it was found that cowpeas would not

grow on the same plots for successive years. Numerous varieties (*see* Appendix II) were obtained in the collection of local edible beans. They varied considerably in cover, time to maturity and seed characters. After trial in observation plots, a few of the more promising varieties have been retained for selection work.

At present the most promising bean is the selection of the local Popondo. It is the only one which in any way approaches mucuna as a cover crop, while at the same time yielding an edible seed. The next few years will show how far it is comparable with mucuna in the plantation rotation trials. At the same time it must be recognised that Popondo does not represent the ideal type. In view of the possibility of a future export trade, the seed characters will have to be improved. The yellow discolouration of the testa would be a serious handicap were the seed to compete with the Lima beans of commerce. As a "cover" also, Popondo might be improved.

It would seem that in future attention may have to be paid to the question of hybridisation. Although imported bean types have generally failed, some of their more desirable features might be bred into Popondo. From crosses between Popondo and Lima there should be progeny having greater yields and, possibly, an increased volume of growth resulting from "hybrid vigour". In some of the samples of local edible beans progeny of natural crosses have been found, some of which seem very promising. It is certain that, if the native farmer is to take it up, the bean must be considerably better than anything at present grown.

Acknowledgments.

The botanical work on beans recorded in this paper was inaugurated and carried out by Messrs. C. J. Lewin, C. B. Taylor, E. H. G. Smith and A. V. Gibberd. The writer has attempted to summarise their work and identify the various types of beans which are here mentioned.

APPENDIX I.

Beans which yield an Edible Seed and practically no Cover.

A.—Phaseolus vulgaris:

Kidney, Haricot or French beans. These are dwarf or climbing beans which generally mature early. The pods can be eaten green or allowed to ripen for the seeds.

Natal Sugar.—Rhodesia. Dwarf habit; pale purple flowers; medium sized brown mottled oval kidney seeds; maturing in about nine weeks.

Parisian.—Rhodesia. Dwarf habit; purple flowers; large sized red-brown oval kidney seeds; maturing in about nine weeks.

Lyonnais.—Rhodesia. Dwarf habit; purple flowers; small sized flat dark brown seeds; maturing in about nine weeks.

White Haricot.—Dublin, Ireland. Climbing habit; early maturing.

Murunga.—Ceylon. Climbing habit; white flowers; white oval kidney seeds, 135 to the ounce; maturing in about ten weeks.

Dwarf French.—(i) Ceylon. Dwarf habit; pink flowers; red brown mottled kidney seeds, 115 to the ounce; maturing in about nine weeks.

(ii) Cameroons. Dwarf habit; white flowers maroon kidney seeds, 80 to the ounce; maturing in about nine weeks.

(iii) Cameroons. Dwarf habit; pink flowers; oval black seeds, 140 to the ounce; maturing in about nine weeks.

(iv) Cameroons. Low climbing habit; white flowers; round white seeds, 160 to the ounce; maturing in about ten weeks.

Ohtenashi.—(i) Imperial Institute. Low climbing habit; white flowers; white oval seeds, 142 to the ounce; maturing in about nine weeks.

(ii) Zaria, from Imperial Institute. Low climbing habit; white flowers; white oval seeds, 122 to the ounce; maturing in about nine weeks.

Kotenashi.—Imperial Institute. Low climbing habit; white flowers; white oval seeds, 122 to the ounce; maturing in about nine weeks.

Danubian.—Zaria, from Imperial Institute. Low climbing habit; white flowers; white oval seeds, 110 to the ounce; maturing in about nine weeks.

B.—Phaseolus acutifolius:

Tepary bean.—Rhodesia. Bush habit; small white flowers; medium large white oval seeds; maturing in about ten weeks.

C.—Phaseolus mungo:

Green gram.—Nyasaland. Dwarf habit; yellow flowers; olive green blunt ended seeds, 875 to the ounce; thin many seeded black pods; maturing in about ten weeks.

D.—Glycine hispida.—Soy bean

O-too-tan.—Rhodesia. Bush habit; small purple flowers; small rounded black seeds; maturing in about 11 weeks.

E.—Voandzeia subterranea:

Bambarra groundnut. Dwarf habit; very small yellow flowers; round seeds borne singly in hard capsules underground; maturing in three to four months.

Gudjiya.—Sokoto. Small round yellow and black seeds.

Gudjiya.—Zaria. Large round yellow seeds streaked red and black.

Kwaruru.—Badeggi. Large round yellow and black seeds.

F.—Sphenostylis spp.— A local climbing bean; large pink flowers; small round seeds; pods thin; up to 25 cms. long, black when ripe; late maturing.

Odudu.—Umuahia. Small round black seeds.

Ikhekhe or Ihiehie.—Benin. Small round brown or black seeds.

Sheshe.—Badeggi. Small round yellow seeds.

APPENDIX II.

VARIETIES OF COWPEAS COLLECTED THROUGH THE OUT-STATIONS.

Vigna catjang.—Cowpea. Creeping or voluble habit; flowers white or coloured, borne on upright peduncles; pods long, thin, many seeded; seeds white or coloured, variable in size and shape. The varieties which have been tried out may be grouped according to the seed characters. The native names, where possible, are given in brackets.

(1) Seeds large, rough coated, white with pale blue, brown or black halos round the hilum. Flowers white. This type gave the best yields and cover. Specimens were received from Zaria, Ilorin, Sokoto (Sa Baba Sata), Badeggi (Langbazo) and Kano.

(2) Seeds large, smooth coated, dark brown. Flowers coloured. A specimen was received from Sokoto (Kwama).

(3) Seeds large, wrinkle coated, dark brown. Flowers coloured. A specimen was received from Ilorin.

(4) Seeds medium, smooth coated. Flowers coloured. Specimens were received from Cameroons as follows:— Pale yellow to brown (Makon); brown with purple speckle (Akwon); Orange to fawn (Oloboi).

(5) Seeds small, smooth coated. Flowers coloured. Specimens were received as follows:—Brown coloured from Cameroons (Bande or Makwe); brownish red from

Shika (Jan Wake), from Kano (Tsarariya) and Benin (Iheme); pale brown with brown speckle from Zaria (Kwama); olive brown from Benin (Ihilen); and purple brown from Nyasaland.

(6) Hybrid types showing all degrees of colour and shape. Specimens were received from Shika; black and white (Bakin Waka); brown and white (Kargo); brown and white (Kashin Zomo); and black and white streaked (Kashin Kaji); from Badeggi, black and brown (Yawa), and brown and white (Munugi).

The large white seeded types appeared to be the more successful.

APPENDIX III.

Varieties of *Phaseolus lunatus*, lima or butter beans. Annual, and occasionally perennial, climbing beans. The flowers are small, the keel spirally twisted and the standard green.

The types collected have been grouped provisionally as follows:—

Group A. *Popondo.*—Terminal leaflets with square bases, the leaf width being generally about two-thirds of the length. These are robust native beans which mature late and produce a considerable volume of growth. They give large flat pods and large flat kidney seeds. The flowers may be white or pink and the stems green or reddish. Seed colour varies considerably, but white seeds seem to be correlated with white flowers and green stems.

Group B. *Lima Small or Rangoon.*—Terminal leaflets with round bases, the leaf length being frequently greater than the width. These are less robust beans which mature early. The foliage is not so dense or the leaves as large and thick as in group A. They produce small flat pods and small flat or oval seeds. Similar variations of flower and seed colour have been observed as for group A.

Group C. *Lima Large or Madagascar.*—An intermediate type in which the pod and seed characters of group A are combined with the leaf characters of group B.

Group A will appear to correspond with the type of bean referred to in American literature as *P. limensis* or *P. lunatus macrocarpus*, and group B with *P. lunatus*. Hybrids of groups A and B show many degrees of variation and admixture of characters.

ANNUAL REPORT—MOOR PLANTATION, IBADAN, NIGERIA—1930.

The following officers were in charge:—

J. R. V. Smyth, January 1st to June 21st., December 25th to December 31st.

A. E. Trotman, June 22nd to August 18th.

O. J. Voelcker, August 19th to December 24th.

The experiments and investigations carried out during 1930 were continued on the same lines as in previous years, the details having already been given in the bulletins published

From results obtained from the different cover crop experiments there appears to be little doubt that yields can be maintained by the use of cover crops only. Our next aim is to discover the most suitable bean to grow which will serve as a cover, will maintain fertility, and in addition will produce seed of value as a foodstuff. Various beans are being grown with this object in view.

As will be seen from Table I in the Appendix, the rainfall during the year was slightly higher than the average for the last twenty-one years and all crops benefited by very favourable weather conditions. The unusually heavy rainfall during March resulted in very satisfactory yields being obtained from early planted crops, while with the yam crop considerable increases were recorded over yields obtained during the last seven years; the yields approaching the maximum recorded on the plantation. The increased yields of yams may in part be accounted for by the burying of sets in pits before planting out and the consequent higher germination obtained from sets planted.

Higher yields than usual were also obtained from the late maize crop which benefited by the two falls of rain in December, just before the crop ripened off.

All cotton grown on the plantation was of the Ishan variety and satisfactory yields well up to the average of 400 lb. per acre were obtained, 84% of the cotton grown being first grade. Generally all crops were healthy; a proportion of the yam crop suffered from scab disease while groundnuts suffered from minor attacks of Tikka and Sclerotium.

Y1S. Cover Crop Experiment, 1930.

TABLE 2.

Acreage 3.6—Commenced 1922.

Cropping.—Maize and beans each year.

Object.—(*i*) To study the effect of various treatments during the dry season.

(*ii*) To compare the efficiency of various legumes as late season cover crops.

Routine.—Beans ridged in March; maize planted in April; beans interplanted in June.

	Yields in lb. per acre.	Odds that the difference is significant.
Average yield of 10 plots following Dolichos	1,386	—
Average difference of 2 plots following Canavalia	− 41±176	—
Average difference of 2 plots following Mucuna	− 79±176	—
Average difference of 2 plots following Cowpeas...	+ 93±176	—
Average difference of 1 plot Dolichos dug December 1st	+ 63±248	—
Average difference of 1 plot Weeds ...	+307±248	8 : 1
Average difference of 1 plot Weeds cultivated December 1st and January 1st	− 94±248	--

The best covers were again afforded by Mucuna and Dolichos while cowpeas and Canavalia proved to be of little value. An increase of 196 lb. of maize over last year's figure is recorded on the Dolichos control plots which gave an average yield of 1,386 lb. dry grain per acre, the highest figure yet recorded from this block.

Though Mucuna afforded the best cover on the two plots concerned the yield after Dolichos continues to be higher than that after Mucuna.

	1924 lb.	1925 lb.	1926 lb.	1927 lb.	1928 lb.	1929 lb.	1930 lb.
Average yield of 10 plots after Dolichos	1,225	546	1,243	1,357	1,337	1,190	1,386
Average difference of 2 plots after Canavalia	+ 42	− 10	−171	−225	−285	−154	− 41
Average difference of 2 plots after Mucuna	−115	− 18	−111	− 92	− 83	− 25	− 79
Average difference of 2 plots after Cowpeas...	−203	+ 31	−145	−123	− 59	—	+ 93
Average difference of 1 plot after Dolichos dug in December 1st	+223	+186	+ 54	− 95	− 98	+ 33	+ 63
Average difference of 1 plot after Weeds	−311	−146	−516	−464	+133	+173	+307
Average difference of 1 plot cultivated December 1st and January 1st	−225	− 70	−311	−172	−345	−144	− 94

B7 & 8. Dry Season Treatment of Cover Crop Experiment, 1930.

TABLE 3.

Acreage $4\frac{1}{4}$—Commenced 1925.

Cropping.—1926-1930. Maize and Mucuna each year.

Object.—To compare the effect of digging in a cover crop green with that of allowing it to stand and mature during the dry season.

Routine.—"Even" plots (2-16), cover crop to be cut in March and dug in at once.

"Odd" plots (1-17), cover crop to be cut in October and dug in at once.

Maize planted in April, Mucuna interplanted in June.

	Yield in lb. per acre.	Odds that the difference is significant.
Average yield of 9 plots dug in at the beginning of dry season	2,292	—
Average difference of 8 plots dug in at the end of dry season	−211±63	4,000 : 1

Yields:—

1926.	*1927.*	*1928.*	*1929.*	*1930.*
lb.	lb.	lb.	lb.	lb.
2,308	1,652	1,903	1,974	2,292.
−102±90	−60±59	−86±50	−121±54	−211±63

The results obtained during the last four years are again confirmed; the difference between the two treatments being still more pronounced. Higher yields of early maize result when land is ridged at the commencement of the dry season rather than immediately before the rains. The experiment has been of great interest in showing the advantages of early ridging, a result which was scarcely anticipated when the experiment was laid down in view of the fact that the ground is left bare for several months. This experiment having served its purpose has been discontinued.

C5N. Treatment of Cover Crop Experiment, 1930.

TABLES 4a and 4b.

Acreage 5—Commenced 1925.

Cropping.—1926-1930. Maize and Mucuna each year.

Object.—(*i*) To compare the effects of digging and moulding up as methods of preparatory cultivation.

(*ii*) To compare the effects of digging in the cover crop green, and of allowing the cut cover crop to remain on the surface to rot before digging in.

Routine.—Plot 1. Cover crop cut in February and dug in at once. Plots 2-10, cover crop to be burnt in February, the " Even " plots to be ridged and " Odd " plots moulded. Plots 11-19, cover crop cut in November, the " Odd " plots to be ridged immediately, and " Even " plots left to rot, to be ridged in February. Plot 20, cover crop to be burnt in February and ridged at once.

Maize planted in April, Mucuna interplanted in June.

TABLE 4a.

	Yield in lb. per acre.	Odds that the difference is significant.
Average yield of 5 plots burnt in February and dug in at once	1,605	—
Average difference of 4 plots burnt in February and moulded at once	+25±57	—

Yields:—	1926. lb.	1927. lb.	1928. lb.	1929. lb.	1930. lb.
	2,098	1,523	1,622	1,741	1,605
	+30±30	+99±67	−105±47	−229±43·8	+25±57

In the moulding and ridging trial the moulded ridges have given a slight but insignificant increase over those ridged. The moulded ridges have not been split since 1925 and in 1928 and 1929 gave lower yields than the ridged plots.

TABLE 4b.

	Yield in lb. per acre.	Odds that the difference is significant.
Average yield of 5 plots cut in November and dug in at once ...	1,901	—
Average difference of 4 plots cut in November left to rot, dug in February	−193±29	∞ : 1

Yields:—	1926. lb.	1927. lb.	1928. lb.	1929. lb.	1930. lb.
	2,269	1,631	1,908	1,914	1,901
	−22±122	−169±128	−102±112	−144±144·5	−193±29

The plots ridged in during November again give higher yields than the plots ridged in February, confirming last year's results and also those obtained from the Dry Season Treatment of Cover Crop Experiment.

Main Rotation.

(Maize and Cover Crop, Yams and Cover Crop, Green Manure and Cotton, Groundnuts, Cover Crop.)

A6S.—Groundnuts, 1930. "Acclimatisation Test."

TABLE 5.

Acreage 5—Commenced 1929.

	Yield in lb. per acre.	Odds that the difference is significant.
Average yield of 10 plots of Acclimatised Zaria	1,665	—
Average difference of 9 plots of newly imported Zaria ...	−1±32	—

The newly imported Zaria showed little variation on germination and growth when compared with the acclimatised Zaria and the yields from the two types were very similar. This experiment will be carried out during 1931 and 1932 with acclimatised Zaria seed grown three and four years respectively on the plantation and newly imported Zaria seed.

Main Rotation.

B4W.—Groundnuts, 1930. "Normal weeding" *versus* "No weeding after flowering."

TABLE 6.

Acreage 5—Commenced 1922.

	Yield in lb. per acre.	Odds that the difference is significant.
Average yield of 10 plots weeded after flowering	1,345	—
Average difference of 9 plots not weeded after flowering	−130±38	4,000 : 1

This experiment was started with the object of investigating the effect of leaving groundnuts unweeded after flowering started. The results show that weeding is definitely beneficial with groundnuts after flowering has commenced.

The costings of the Main Rotation.

First year	Green manure and yams.
Second year	Green manure and cotton.
Third ,, ...	Groundnuts.
Fourth ,, ...	Green manure and maize.

The tables published in the last four bulletins showing the cost of production of the main rotation have been revised in the following summary for the years 1926-1930. The costs of the three green manure crops have now been charged against the crop that follows them and not to the crop in the same "course" of the rotation. In previous bulletins a table has been published showing

a comparison between the cost of production and revenue but it is considered that the figure for the " yield per man-day " gives a better comparison from year to year than the " net monetary return per man-day ". Any local variation in market prices and cost of labour in the direct comparison is liable to give an inaccurate impression.

ANALYSIS OF THE COST OF PRODUCTION OF ONE ACRE OF MAIN ROTATION CROPS, MOOR PLANTATION, 1930.

	Yams.		Cotton.		Ground-nuts.	Maize.		Total.		4 acres.
	G.M.	Y.	G.M.	C.	G'n.	G.M.	M.	G.M.	Crops.	
Preparation	3	36	...	30	10	4	33	7	109	116
Establishing	2	16	8	7	18	4	12	14	53	67
After cultivation	9	120	28	28	24	6	16	43	188	231
Harvesting	...	52	...	13	62	...	13	...	140	140
Total	14	224	36	78	114	14	74	64	490	554

In the above analysis of the cost of production :—

Preparation includes preparation of land and seed;

Establishing includes planting, supplying, thinning;

After cultivation includes all work necessary between establishing and harvesting;

Harvesting includes reaping the crop, weighing in the field and transport to store.

COMPARISON BETWEEN COST OF PRODUCTION AND YIELDS FROM THE MAIN ROTATION, 1926-30.

	YAMS.				COTTON.				GROUNDNUTS.			MAIZE.			
	Cost of green manure crop in man-days per acre.	Cost of yam crop in man-days per acre.	Average net yield of yams in lb. per acre.	Yield of yams in lb. per man-day.	Cost of green manure crop in man-days per acre.	Cost of cotton crop in man-days per acre.	Average yield of seed cotton in lb. per acre.	Yield of seed cotton in lb. per man-day.	Cost of groundnut crop in man-days per acre.	Average yield of dry unde-corticated nuts in lb. per acre.	Yield of groundnuts in lb. per man-day.	Cost of green manure crop in man-days per acre.	Cost of maize crop in man-days per acre.	Average yield of maize in lb. of dry grain per acre.	Yield of maize n lb. per man-day
1926 ...	29	254	4,884	17	26	109	212	1·6	136	1,653	12	19	67	1,982	23
1927 ...	11	146	5,452	35	88	81	50	0·3	100	1,086	11	18	65	1,208	15
1928 ...	15	109	3,081	25	16	104	631	5·2	124	1,793	14	17	60	1,980	26
1929 ...	13	176	3,161	17	32	101	405	3·0	121	1,394	11	23	60	2,088	25
1930 ...	14	224	7,919	33	36	78	370	3·3	114	1,505	13	14	74	2,061	23

The crop yields are the averages of the control plots of the Main Rotation blocks. The varieties are as follows:—

Yams—Iyawo. Maize—Lagos white. Cotton—Improved Ishan. Groundnuts—Zaria (Moor Plantation).

1927 was a particularly unfavourable season for early maize and cotton on the farm and the Ibadan district generally.

D2.—Continuous Yams and Mucuna Experiment.

Acreage 4—Commenced 1930.

This was the first year of this experiment on the cultivation of yams interplanted with Mucuna continuously for a number of years. Carefully selected sets from newly imported Iyawo yams were used for planting up the land which had been fallow since 1928; a gross average yield of 14,292 lb. per acre was obtained. The growth of the interplanted Mucuna was excellent.

Three-year Rotation.

TABLE 7.

C3W.—Yams, 1930. "Time of Planting Test".

Acreage 5—Commenced 1928.

1928	...	...	Maize, late maize, mucuna.
1929	...	...	Mucuna.
1930	...	...	Yams, cotton.

A "Time of Planting Test" was again carried out with yams on this block. Results obtained last year indicated the best month to plant yams on Moor Plantation to be November, February the next best then December and January.

This year the control plots were planted on 23rd November, three treatment plots a fortnight later, three treatment plots each a fortnight and a month earlier. None of these gave significantly higher or lower yields. It was noticed that the early death of many yam vines was correlated with the scab disease but apart from these and patches where gravel outcrops the yams from all plots appeared ready to harvest at the same time.

Gross yields in lb. per acre:—

					1924.	*1930.*	
					10,629	12,264.	
					Yields in lb. per acre. Gross	Nett.	Odds.
Average yield of	10	plots	planted	23/11/29	12,213	9,117	
„ difference „	3	„	„	9/11/29	+ 445 ± 786	+ 246 ± 769	3 : 1
„ „ „	3	„	„	26/10/29	− 140 ± 786	− 357 ± 769	—
„ „ „	3	„	„	7/12/29	+ 173 ± 786	+ 65 ± 769	—

THREE-YEAR ROTATION.

TABLE 8.

A5N.—YAMS AND MUCUNA, 1930.

ACREAGE 5—COMMENCED 1928.

Routine.—Odd and Even plots, yams sown in November. Cotton to be interplanted in July.

Cropping.	*Treatment* (Even plots.)	*Control* (Odd plots.)
(1928)	Maize and late maize cover crop	Green manure late maize
(1929)	Green manure continued until October	Maize and cover crop
(1930)	Yams and cotton	Yams and cotton.

Significantly higher yields were obtained from the yams and cotton grown on the control plots indicating the desirability of two short season green manure crops as against one whole season green manure crop following two maize crops grown in one year.

B3E.—GREEN MANURING EXPERIMENT.

TABLE 9.

ACREAGE 3¼—COMMENCED 1923.

Object.—To compare the efficiency of various leguminous crops for the purpose of green manuring.

Cropping.—Beans and late maize each since 1923 with the exception of 1924 and 1926 when cotton replaced late maize.

Routine.—Late maize harvested, stalks removed. Beans planted in March, stand one foot apart on each side of the ridge. Beans to be dug in in August. Late maize planted in September. Mucuna "Odd" plots; Amberique beans plots 2 and 8; Centrosema plots 4 and 10; Calopogonium plots 6 and 12.

	Yield in lb. per acre.	Odds that the difference is significant.
Average yield of 7 plots with Mucuna	1,624	
„ difference „ 2 „ „ Amberique	− 272 ± 90	740 : 1
„ „ „ 2 „ „ Centrosema	− 762 ± 90	∞ : 1
„ „ „ 2 „ „ Calopogonium	− 74 ± 90	4 : 1

	1923.	1925.	1927.	1928.	1929.		1930.	
Mucuna...	1,053	1,054	1,356	1,601	Mucuna	1,540	Mucuna	1,624
Dolichos	+ 86	− 23	+ 41	−174	Dolichos	− 128	Amberique	− 272
Canavalia	+ 46	+ 26	−110	−237	Lima	− 366	Centrosema	− 762
Cowpeas	+ 64	−126	− 38	−104	Calopogonium	− 8	Calopogonium	−74

An excellent crop of maize was grown on the block and the average yield after the Mucuna on the control plots was the highest recorded since the experiment commenced. This year Amberique beans replaced Dolichos and Centrosema replaced Lima. Mucuna and Amberique formed good covers but Centrosema proved unsuitable as it was difficult to establish and afforded very little cover. Difficulty was experienced in establishing Calopogonium in the early stages of its growth but before being turned in an excellent thick cover was evident.

The following figures give an indication of the approximate weights in lb. per acre of green manures turned in when the land was ridged for the late maize crop on 12th August:—

1930.		*1929.*		*1927.*	
Mucuna ...	21,970	Mucuna ...	15,738	Mucuna ...	17,380
Amberique	20,570	Dolichos ...	11,968	Dolichos ...	13,530
Calopogonium	19,008	Calopogonium	20,614	Cowpeas ...	3,630
Centrosema	5,544	Lima ...	5,478	Canavalia	2,640

Nursery.

The following plants were distributed during the year:—

Coconut plants	219
Kola ,, ...	1,682
Cocoa ,, ...	69
Coffee ,, ...	6
Oil palms ,, ...	14
Ornamental plants	6,027
Budded, grafted and seedling fruit trees	3,361
Total	11,378

Poultry: Breed—Rhode Island Red.

An increased head of stock is now being maintained and it is now possible to meet demands for supplies of eggs. Similarly, the distribution of young cockerels and pullets will be possible once our stock has been brought up to strength.

A total of 1,325 eggs and six Rhode Island Red cockerels were distributed during the year.

TABLE No. 1.

METEOROLOGICAL REPORT FOR 1930.

Moor Plantation.

Hours of observation, 9 a.m. and 2 p.m.

Months.	AIR TEMPERATURE.							Average Relative Humidity.		1930 rainfall in inches.	No. of days rain fell 1930.	Average for 21 years 1910 to 1930.
	Means.		Range.	Absolute.								
	Max.	Min.		Max.	Date.	Min.	Date.	9 a.m.	2 p.m.			
January ...	92·2	64·2	28·0	96·9	14th ...	54·8	23rd ...	88	59	0·05	1	0·37
February ...	97·2	73·4	23·8	101·0	16th ...	65·0	2nd ...	88	61	0·14	1	0·77
March ...	94·5	71·7	22·8	101·0	4th ...	66·0	5th ...	87	66	6·35	12	3·48
April ...	91·2	69·6	21·6	95·4	5th ...	62·0	26th ...	90	87	2·88	6	5·64
May ...	91·1	70·2	20·9	95·5	3rd ...	66·0	31st ...	91	79	4·24	14	5·97
June... ...	87·3	69·3	18·0	91·6	10th ...	62·0	21st ...	93	89	9·40	20	7·62
July... ...	83·1	70·6	12·5	96·0	4th ...	65·5	24th ...	93	83	7·50	23	6·23
August ...	83·3	68·9	14·4	87·3	19th ...	65·6	27th ...	89	78	2·04	12	3·19
September ...	86·2	70·3	15·9	90·5	8th ...	66·4	16th ...	90	73	8·12	15	7·27
October ...	88·2	70·5	17·7	92·5	26th ...	66·2	29th ...	88	65	7·55	15	6·56
November ..	91·7	69·0	22·7	96·0	9th ...	62·0	26th ...	88	58	0·27	2	1·84
December ...	88·3	71·3	17·0	93·8	14th, 15th	67·4	12th ...	89	71	1·58	3	0·24
Total	...	...	...	...	...	...	...	...		50·12	124	49·18
Means ...	89·5	69·9	19·6	94·8	...	64·0	...	89·5	72·4	...	...	...

TABLE No. 2.

Cover Crop Experiment.

Block Y1S.		Treatment.	Yield of Maize in lb. of Dry grain per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Plot Nos.	Crop.		Controls.	Treatment.	
21	Maize.	Dolichos	1,400		
22	„	Canavalia		1,524	− 83
23	„	Dolichos	1,814		
24	„	Mucuna		1,415	− 129
25	„	Dolichos	1,274		
26	„	Cowpeas		1,319	+ 57
27	„	Dolichos	1,250		
28	„	Canavalia		1,188	−
29	„	Dolichos	1,127		
30	„	Mucuna		1,138	− 30
31	„	Dolichos	1,210		
32	„	Cowpeas		1,395	+ 129
33	„	Dolichos	1,322		
34	„	Dolichos dug December 1st		1,494	+ 63
35	„	Dolichos	1,541		
36	„	Weeds		1,800	+ 307
37	„	Dolichos	1,444		
38	„	Weeds cultivated December 1st and January 1st		1,369	− 94
39	„	Dolichos	1,482		
40	„	Dolichos: Non-experimental		(1,627)	—

Average yield of 10 plots Maize following Dolichos			...	1,386 lb. per acre.
„ difference	2	„ „ „ Canavalia	...	− 41±176 „ „
„ „	2	„ „ „ Mucuna	...	− 79±176 „ „
„ „	2	„ „ „ Cowpeas	...	+ 93±176 „ „
„ „	1	plot Dolichos dug Dec. 1st ...	...	+ 63±248 „ „
„ „	1	„ Weeds	...	+307±248 „ „
„ „	1	„ Weeds cultivated December 1st and January 1st	...	− 94±248 „ „

Root—mean—square—difference between neighbouring control plots = 248

Plots. 18 acre. Ridges 6′ apart. Stands 18″ in double rows. Maize (Lagos White variety) planted 2½″ deep ; 1 plant per stand ; supplied as necessary.

Germination = 88%. Percentage dry grain to cob = 80%.

Cost of Experiment in man-days per acre = 111.

Cultivation :—Ridged plot 34 on 30th November, 1929 ; remainder on 20th February, 1930. Planted 31st March, 1930 ; Supplied 9th April, 1930 ; Thinned 22nd April, 1930 ; Weeded 24th March, 1930 ; Harvested 6th August, 1930 ; Beans planted 14th June, 1930.

TABLE No. 3.

Dry Season Treatment of Cover Crop.

Blocks B7 and 8.		Treatment.	Yield in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Plot Nos.	Crop.		Control.	Treatment.	
1	Maize.	Cut and dug in October ...	2,068		
2	,,	Cut and dug in February		2,220	+ 35
3	,,	Cut and dug in October ...	2,302		
4	,,	Cut and dug in February		2,248	− 159
5	,,	Cut and dug in October ...	2,512		
6	,,	Cut and dug in February		2,204	− 246
7	,,	Cut and dug in October ...	2,388		
8	,,	Cut and dug in February		2,176	− 78
9	,,	Cut and dug in October ...	2,120		
10	,,	Cut and dug in February		1,956	− 153
11	,,	Cut and dug in October ...	2,098		
12	,,	Cut and dug in February		1,880	− 327
13	,,	Cut and dug in October ...	2,316		
14	,,	Cut and dug in February		2,024	− 306
15	,,	Cut and dug in October ...	2,344		
16	,,	Cut and dug in February		1,960	− 455
17	,,	Cut and dug in October ...	2,486		

Average yield of 9 control plots dug in October 31st ... 2,292 lb. per acre.

,, difference of 8 treatment plots dug in February 20th − 211 ± 63.

Root—mean—square—difference between neighbouring control plots = 178.

Plots $\frac{1}{4}$ acre. Ridges 6′ apart. Stands 18″ in double rows. Variety: Lagos White. Planted $2\frac{1}{2}$″ deep. Thinned to 1 plant per stand when 18″ high. Supplied as necessary.

Germination = 95%. Percentage of dry grain to cob = 79%.

Cost of Experiment in man-days per acre = 88.

Cultivation:—Ridged "Odd" plots 31st October, 1929 "Even" plots 20th February, 1930. Planted 25th March, 1930; Supplied 5th April, 1930; Thinned 15th April, 1930; Weeded 29th November, 1929, 24th March, 7th April, 2nd May and 7th June, 1930. Harvested 30th July, 1930. Mucuna planted 11th June, 1930.

Cover Crop:—planted 1′ apart on both sides of ridges. One or more seed to a hole, depending on variety of bean, supplied as necessary.

TABLE No. 4a.

Treatment of Cover Crop.

Block C5N.		Treatment.	Yield in lb per acre.		Increase (+) or Decrease (−) compared with mean of adjacent controls.
Plot Nos.	Crop.		Control.	Treatment.	
1	Maize	Cut in February, dug in at once ...		1,550	
2	,,	Burnt in February, dug in at once ...	1,540		
3	,,	,, ,, ,, moulded ...		1,712	+ 112
4	,,	,, ,, ,, dug in at once...	1,660		
5	,,	,, ,, ,, moulded ...		1,714	+ 58
6	,,	,, ,, ,, dug in at once...	1,652		
7	,,	,, ,, ,, moulded ...		1,752	+ 84
8	,,	,, ,, ,, dug in at once...	1,684		
9	,,	,, ,, ,, moulded ...		1,436	− 152
10	,,	,, ,, ,, dug in at once...	1,492		

Average yield of 5 plots burnt in February and dug in ... ... 1,605 lb.
,, difference of 4 plots burnt in February and moulded ... + 25±57 ,,
Root—mean—square—difference between neighbouring control plots = 114 lb.

Germination = 92%. Percentage of dry grain to cob = 78%.

Cultivation:—Ridged 24th February, 1930; Planted 24th March, 1930; Supplied 5th April, 1930; Thinned 15th April, 1930; Weeded 14th April, 2nd May, 2nd June and 21st June, 1930; Harvested 29th July, 1930. Mucuna planted 11th June, 1930.

TABLE No. 4b.

Block C5N.		Treatment.	Yield in lb per acre.		Increase (+) or decrease (−) compared with mean of adjacent control.
Plot Nos.	Crop.		Control.	Treatment.	
11	Maize	Cut in November, dug in November	1,974		
12	,,	,, ,, ,, ,, ,, February		1,740	− 217
13	,,	,, ,, ,, ,, ,, November	1,940		
14	,,	,, ,, ,, ,, ,, February		1,654	− 288
15	,,	,, ,, ,, ,, ,, November	1,944		
16	,,	,, ,, ,, ,, ,, February		1,764	+ 124
17	,,	,, ,, ,, ,, ,, November	1,832		
18	,,	,, ,, ,, ,, ,, February		1,680	− 144
19	,,	,, ,, ,, ,, ,, November	1,816		
20	,,	,, ,, February ,, ,, at once ...		(620)	

lb. per acre.
Average yield of 5 plots cut in November and dug in 1,901
Average difference of 4 plots cut in November left to rot and dug in February ... ... −193±29
Root–mean—square—difference between neighbouring control plots = 59 lb.
Plots ¼ acre. Ridges 6′ apart; Stand 18″ in double rows; Maize (Lagos White variety) planted 2½″ deep; Thinned to one plant to a stand when 18″ high. Supplied as necesssry.
Germination = 92%. Percentage dry grain to cob = 78%.
Cost of Experiment in man-days per acre = 79.
Cultivation: Ridged "Odd" plots 8th November, 1929, "Even" plots 24th February, 1930; Planted 24th March, 1930; Supplied 5th April, 1930; Thinned 15th April, 1930; Weeded 14th April, 2nd May, 2nd June and 21st June, 1930. Harvested 29th July, 1930. Mucuna planted 11th June, 1930.

TABLE No. 5.

GROUNDNUTS : " ACCLIMATISATION TEST ".

BLOCK A6S.		Treatment.	YIELD IN lb PER ACRE. Dry Unshelled Nuts.		Increase (+) or Decrease (−) compared with mean of adjacent controls.
Plot Nos.	Crop.		Controls.	Treatments.	
21	Groundnuts	Acclimatised, Zaria	1,830		
22	,,	Newly imported, Zaria		1,748	− 41
23	,,	Acclimatised, Zaria	1,748		
24	,,	Newly imported, Zaria		1,476	− 316
25	,,	Acclimatised, Zaria	1,836		
26	,,	Newly imported, Zaria		1,734	− 122
27	,,	Acclimatised, Zaria	1,876		
28	,,	Newly imported, Zaria		1,712	− 69
29	,,	Acclimatised, Zaria	1,686		
30	,,	Newly imported, Zaria		1,660	+ 5
31	,,	Acclimatised, Zaria	1,624		
32	,,	Newly imported, Zaria		1,768	+ 138
33	,,	Acclimatised, Zaria	1,636		
34	,,	Newly imported, Zaria		1,614	+ 46
35	,,	Acclimatised, Zaria	1,500		
36	,,	Newly imported, Zaria		1,636	+ 174
37	,,	Acclimatised, Zaria	1,424		
38	,,	Newly imported, Zaria		1,634	+ 175
39	,,	Acclimatised, Zaria	1,494		
40	,,	do. do.		(1,684)	

Yield in lb. per acre.

Average yield of 10 plots Acclimatised 1,665

Average difference of 9 plots Newly imported ... ... −1±32

Root—mean—square—difference between neighbouring controls = 97 lb.

Plots ¼ acre. Ridges 6′ apart ; Stands 1′ apart both sides of ridges ; Two undecorticated nuts to a hole. Decorticated nut for supplying. Seed sown 3″ deep

	Acclimatised, Zaria.	Newly Imported, Zaria.
Germination	84%	80%
Percentage Kernels in dry undecorticated nuts	73%	67%

Cost of Experiment in man-days per acre = 108.

Cultivation :—Groundnuts planted 12th March, 1930 ; Supplied 3rd April, 1930 ; Weeded 7th and 15th April, 2nd and 28th May, 17th June and 10th July, 1930. Harvested 22nd August, 1930.

TABLE No. 6.

GROUNDNUTS: "NORMAL WEEDING" *v.* "NO WEEDING AFTER FLOWERING".

BLOCK B4W.		Treatment.	YIELDS IN LB. PER ACRE OF DRY UNSHELLED NUTS.		Increase (+) or Decrease (−) compared with mean of adjacent control.
Plot Nos.	Crop.		Controls.	Treatments.	
1	Groundnuts.	Normal weeding ...	1,230		
2	,,	No weeding after flowering		1,030	− 178
3	,,	Normal weeding ...	1,186		
4	,,	No weeding after flowering		1,134	− 113
5	,,	Normal weeding ...	1,308		
6	,,	No weeding after flowering		1,220	− 188
7	,,	Normal weeding ...	1,508		
8	,,	No weeding after flowering		1,104	− 318
9	,,	Normal weeding ...	1,336		
10	,,	No weeding after flowering		1,108	− 206
11	,,	Normal weeding ...	1,292		
12	,,	No weeding after flowering		1,228	− 64
13	,,	Normal weeding ...	1,292		
14	,,	No weeding after flowering		1,178	− 174
15	,,	Normal weeding ...	1,412		
16	,,	No weeding after flowering		1,468	+ 69
17	,,	Normal weeding ...	1,386		
18	,,	No weeding after flowering		1,444	+ 3
19	,,	Normal weeding ...	1,496		
20	,,	Normal weeding ...	(1,428)		

Yields in lb. per acre

Average of 10 plots weeded 1,345
,, difference of 9 plots not weeded ... . − 130 ±38

Root—mean—square—difference between neighbouring controls = 113.

Plots ¼ acre. Ridges 6′ apart; Stands 1′ apart on both sides of ridges; Two undecorticated nuts to a hole; decorticated nuts for supplying. Seed sown 3″ deep.

Germination = 85%
Percentage Kernels in dry undecorticated nuts = 74%
Cost in Man-days of Experiment = 106.

Cultivation:—Moulded 7th March, 1930; Planted 15th March, 1930; Supplied 3rd April, 1930; Weeded 27th March, 1930, 3rd May, 1930, 19th June, 1930 and 10th July, 1930. Harvested 25th August, 1930.

TABLE No. 7.

YAMS: TIME OF PLANTING.

BLOCK C3W.			YIELD IN LB. (GROSS) PER ACRE.		Increase (+) or Decrease (−) compared with mean of adjacent controls.	YIELD IN LB. PER ACRE (NETT).		Increase (+) or Decrease (−) compared with mean of adjacent controls.
Plot Nos.	Crop.	Variety.	Controls.	Treatments.		Controls.	Treatments.	
		Iyawo planted.						
1	Yams.	23/11/29	10,032			6,904		
2	,,	9/11/29		10,244	− 101		7,116	− 83
3	,,	23/11/29	10,658			7,494		
4	,,	26/10/29		10,260	− 771		6,932	− 991
5	,,	23/11/29	11,404			8,352		
6	,,	7/12/29		12,614	+ 70		9,346	− 142
7	,,	23/11/29	13,684			10,624		
8	,,	9/11/29		15,062	+1,288		11,658	+ 906
9	,,	23/11/29	13,864			10,880		
10	,,	26/10/29		14,188	+ 991		10,828	+ 583
11	,,	23/11/29	12,530			9,610		
12	,,	7/12/29		13,742	+ 245		10,590	+ 97
13	,,	23/11/29	14,464			11,376		
14	,,	9/11/29		13,686	+ 148		10,348	− 86
15	,,	23/11/29	12,612			9,492		
16	,,	26/10/29		11,592	− 640		8,404	− 654
17	,,	23/11/29	11,852			8,624		
18	,,	7/12/29		11,642	+ 203		8,462	+ 239
19	,,	23/11/29	11,026			7,822		
20	,,	23/11/29	(10,116)			(6,860)		

	YIELD IN LB. PER ACRE.	
	Gross.	Nett
Average yield of 10 plots planted 23rd November, 1929	12,213	9,117
,, difference of 3 plots planted 9th November, 1929	+445±786	+246±769
,, ,, ,, 3 ,, ,, 26th October, 1929	−140±786	−357±769
,, ,, 3 ,, ,, 7th December, 1929	+173±786	+ 65±769
Root-mean-square-difference between neighbouring controls	1,361	1,339

Plots ¼ acre. Ridges 6′ apart; Seed or sets planted 20″ apart on top of ridges. Prior to planting out sets are cut and buried in pits; bad and diseased sets discarded before planting. Weight of sets 16 oz.

Germination:—26th October, 1929—87%
9th November, 1929—87%
7th December, 1929—87%
} Controls—23rd November, 1929—83%

Cost of experiment in man-days per acre = 281.

Cultivation:—Ridged 7th October, 1929 and 3rd September, 1930; Marked 15th October, 1929. Weeded 28th October, 1929, 20th November, 1929 and 8th January, 1930. Mulched 10th December, 1929. Mulch removed 16th June, 1930. Harvested 14th October, 1930.

TABLE No. 8.

Three-year Rotation.

Block A 5 N.			Yields in lb. (gross) per acre.		Increase (+) or Decrease (−) compared with mean of adjacent Controls.	Yield in lb. (nett) per acre.		Increase (+) or Decrease (−) compared with mean of adjacent controls.
Plot Nos.	Crop.	Variety.	Controls.	Treatments.		Controls.	Treatments.	
1	Yams	Iyawo	10,232			6,808		
2	,,	,,		9,100	− 803		5,804	− 915
3	,,	,,	9,574			6,630		
4	,,	,,		9,084	+ 850		5,488	− 1,176
5	,,	,,	10,294			6,698		
6	,,	,,		9,034	− 1,059		5,618	− 899
7	,,	,,	9,892			6,336		
8	,,	,,		8,330	− 2,026		5,050	− 1,824
9	,,	,,	10,820			7,412		
10	,,	,,		10,696	− 344		7,336	− 350
11	,,	,,	11,260			7,960		
12	,,	,,		9,914	− 1,073		6,650	− 753
13	,,	,,	10,714			6,846		
14	,,	,,		10,874	− 8		7,502	+ 396
15	,,	,,	11,050			7,366		
16	,,	,,		11,078	− 1,044		7,710	− 1,126
17	,,	,,	13,194			9,990		
18	,,	,,		11,188	− 1,399		7,964	− 1,401
19	,,	,,	11,980			8,740		
20	,,	,,	(10,958)			(7,794)		

N.B.—"Odds" plots ... ... After Maize and Mucuna. "Even" plots after Mucuna.

	Yield in lb. per acre. Gross.	Nett.
Average yield of 10 plots after Maize and Mucuna	10,901	7,510.
,, difference of 9 plots after Mucuna	−956 ± 327	−894 ± 369.

Root—mean—square—difference between neighbouring controls ... 980 (1,107 nett).

Plots ¼ acre. Ridges 6' apart; Seed or sets are cut and buried in pits − bad and diseased sets discarded before planting. Weight of sets 16 oz.

Germination ... 88%

Cost of experiment in man-days per acre = 193.

Cultivation:—Ridged 16th October, 1929. Marked 5th November, 1929. Planted 6th November, 1929. Weeded 21st November, 1929, 4th and 15th January, 1930, 15th and 28th February, 1930, 29th March, 1930, 11th and 25th April, 1930, 15th and 19th May, 1930, 2nd and 23rd June, 1930. Mulched 10th October, 1929. Mulch removed 16th June, 1930. Harvested 8th October, 1930.

TABLE No. 9.

Late Maize—Green Manuring Experiment.

Plot Nos.	B3. Crop.	B3. Ac.	Treatment.	Yield in lb. per acre. Controls.	Yield in lb. per acre. Treatments.	Increase (+) or decrease (−) compared with mean of adjacent controls.
1	Maize	¼	Mucuna	1,240		
2	,,	,,	Amberique		1,024	— 308
3	,,	,,	Mucuna	1,424		
4	,,	,,	Centrosema		812	— 648
5	,,	,,	Mucuna	1,496		
6	,,	,,	Calopogonium		1,480	— 80
7	,,	,,	Mucuna	1,624		
8	,,	,,	Amberique		1,460	— 236
9	,,	,,	Mucuna	1,768		
10	,,	,,	Centrosema		964	— 876
11	,,	,,	Mucuna	1,912		
12	,,	,,	Calopogonium		1,840	— 68
13	,,	,,	Mucuna	1,904		

	Yield in lb. per acre.
Average yield of 7 plots with Mucuna	1,624
,, difference ,, 2 ,, ,, Amberique	− 272 ± 90.
,, ,, ,, 2 ,, ,, Centrosema	− 762 ± 90.
,, ,, ,, 2 ,, ,, Calopogonium	− 74 ± 90

Root—mean—square—difference between neighbouring controls = 127.

Plots ¼ acre. Ridges 6′ apart; Stands 18″ in double rows. Maize (Lagos White variety); Planted 2½″ − 3″ deep. Supplied as necessary. Thinned to 1 plant per stand when 18″ high.

Cost of experiment in man-days per acre = 95.

Germination ... 91%. Percentage dry grain to cob ... ... 78%.

Cultivation: Ridged 12th August, 1930; Planted 27th August, 1930; Supplied 3rd September, 1930; Weeded 10th and 17th September, 1930, 15th November, 1930, 9th October, 1930, 15th November, 1930. Thinned 11th September, 1930. Harvested 17th December, 1930.

Approximate weights of beans dug in on 12th August, 1930:—

Mucuna	21,970 lb. per acre.
Amberique	20,570 ,, ,, ,,
Centrosema	5,544 ,, ,, ,,
Calopogonium	19,008 ,, ,, ,,

TABLE No. 10.

COCONUTS, 1930.

Plot.	Acreage.	Planting distance.	No. of collections.	Total yield of nuts.	REMARKS.
B 1.	5.	30′ × 30′	7	13,372	—
C 1.	5.	25′ × 25′	7	7,043	—

TABLE No. 11.

CACAO, 1930.

Plot.	Acreage.	Variety.	Planted.	YIELD PER ACRE LB.		REMARKS.
				Wet Beans.	Dry Beans.	
A1, N. ...	2·5	Yellow pod	1912	2,677	638	—
Y1, N. ...	4·75	Red pod ...	1912	1,038		

TABLE No. 12.

COFFEE, 1930.

Plot.	Variety.	Acreage.	Yield of fresh berries per plot in lb.	Yield of parchment Coffee per plot in lb.	Yield of parchment Coffee in lb. per acre.	REMARKS.
A2, N.	Arabica	1·00	11	2	2	
A2, S.E.	Abeokuta	1·00	985	166	166	
Y2, S.E.	Liberica	·88	144	21	24	
Y2, S.W.	Braziliensis	·88	286	54	61	

TABLE No. 13.

KOLA, 1930.

Plot.	Acreage.	No. of collections.	No. of pods.	Weight of pods oz.	No. of good nuts.	No. of bad nuts.	Weight of nuts lb.	Yield of nuts in lb. per acre.	REMARKS.
Y5.	2½	9	1,053	577	2,793	1,734	84	34	
A2, S.	2	1	20	9	60	30	2	1	

TABLE No. 14.

Palm Tapping Experiment, 1917-30.

Figures in gallons.

Tree No.	1917.	1918.	1919.	1920.	1921.	1922.	1923.	1924.	1925.	1926.	1927.	1928.	1929.	1930.	Remarks.
1	30·42	14·83	9·00	11·35	6·56	0·78	—	—	—	—	—	—	—	—	Tree felled 1922.
2	28·57	28·29	12·10	11·78	8·62	12·54	5·062	0·11	1·50	1·04	1·74	—	—	—	Finished 1927.
3	18·96	9·69	—	—	—	—	—	—	—	—	—	—	—	—	„ 1923.
4	13·39	16·21	—	—	—	—	—	—	—	—	—	—	—	—	„ 1918.
5	11·32	0·55	5·32	1·02	—	0·95	0·341	—	0·025	—	—	—	—	—	„ 1925.
6	15·78	7·34	—	4·06	—	0·16	—	—	—	—	—	—	—	—	„ 1922.
7	32·29	9·41	17·37	17·43	14·63	7·79	5·123	3·00	0·64	1·20	10·20	3·9	1·050	—	„ 1929.
8	19·18	19·12	1·42	1·37	—	—	—	—	—	—	—	—	—	—	„ 1922.
9	3·66	6·04	6·91*	3·50	2·93	3·61	0·985	0·83	0·26	·016	5·20	4·3	·596	·18	—
10	7·49	8·01	7·25	11·99	5·93	8·03	4·105	0·97	1·50	·98	8·57	13·3	1·915	1·68	—

*Contains 3·76 gallons by stem tapping (done in error).

ANNUAL REPORT—OGBA PLANTATION, BENIN, 1930.

The officer in charge from 1st January to 31st December, 1930, was Mr. J. L. B. Kincaid.

The rains were late in commencing in 1930, and the early maize and cover crops experienced trying conditions during March. In the light, sandy soil of Benin the ridges dry out rapidly. Early sown maize which has germinated and then experiences dry weather suffers severely. This is especially noticeable in the poorer fields on the farm. Cover crops were generally satisfactory throughout the year. Mucuna has been proved to be unsuitable for Benin, but Centrosema and Calopogonium have been found to be very satisfactory. They are both slow growing cover crops, but once they are established last well. Centrosema usually remains green throughout the dry weather, but is liable to die out in poor soil. Calopogonium usually dies back towards the end of the dry season but this depends on the rainfall.

Native Farming *versus* Continuous Cropping Experiment, 1930.

Table 2.

	Nett yield of yams lb. per acre.	Odds that the difference is significant.
Average yield of 9 plots native farming	5,044	—
Average difference of 4 plots continuously cropped and stumped ...	−2,677±732	5,000 : 1
Average difference of 4 plots continuously cropped and unstumped ...	−2,272±732	5,000 : 1

This is the first test crop of an experiment commenced in 1925 to compare plots farmed according to local practice with ridged plots, stumped and unstumped, continuously cropped. The native farming plots were cropped with yams and maize in 1925 and reverted to bush for four years. The continuously cropped plots were

cropped with yams and maize in 1925 and subsequently as follows:—

1926	...	...	...	Centrosema.
1927	...	...	...	Early maize.
1928	...	...	...	Yams.
1929	...	...	...	Centrosema.

The continuously cropped plots have seriously lost in fertility as compared with the native farming plots. All plots received similar treatment as far as possible; the same number of yams being planted in each on the same date. Subsequent cultural operations and harvesting were also carried out at the same time throughout.

Permanent Crops.

Oil palms have made good progress throughout the year.

Block L, a 5-acre field of palms, planted in 1923, has yielded as follows during 1930:—

No. of bunches per acre	...	...	...	462
Wt. of bunches, lb. per acre	...	...	...	2,134
Wt. of fruit, lb. per acre	...	...	...	1,297

Block M, planted in 1923, a comparison of palms in continuously cropped land with palms in land under cover crop has yielded as follows:—

	No. of bunches	*Wt. of bunches lb. per acre.*
Plot 1 Cover crop ...	633	4,125
,, 2 Cropped ...	614	3,389
,, 3 Cover crop ...	598	3,502
,, 4 Cropped ...	598	3,255
,, 5 Cover crop ...	692	3,545

In Block A, the experiment on different planting distances for oil palms, mentioned in the 1928 report, has made good progress. The calopogonium cover crop which was established in 1929 has been very satisfactory throughout. At the beginning of the dry season the young palms received a heavy vegetable mulch of Calopogonium cut from the adjacent cover crop.

TABLE No. 1.

METEOROLOGICAL REPORT FOR 1930.

Ogba Farm Station.

Hour of Observation, 9 a.m.

Months.	AIR TEMPERATURE.							Relative humidity Sat. 100.	1930 Rainfall in inches.	No. of days.	Average rainfall for 8 years.
	Means.		Range.	Absolute.							
	Max.	Min.		Max.	Date.	Min.	Date.				
January ...	92°	63°	29°	97°	11th, 12th, 13th	54°	1st, 5th, 18th	88	1·53	3	1·16
February ...	95°	71°	24°	98°	24th ...	66°	27th ...	88	1·11	3	1·22
March ...	94°	70°	24°	99°	11th ...	67°	9th ...	83	·86	8	3·17
April ...	93°	71°	22°	97°	6th ...	64°	25th ...	89	5·54	11	6·07
May	93°	69°	24°	97°	7th, 8th, 9th, 17th, 18th, 31st	66°	30th, 31st	88	5·79	14	7·12
June	90°	67°	23°	95°	9th ...	65°	21st, 25th	89	4·67	21	11·57
July	85°	66°	19°	92°	18th ...	62°	24th, 30th, 31st	92	12·03	23	11·52
August ...	84°	66°	18°	91°	18th ...	63°	15th, 25th	93	11·99	21	7·45
September ...	86°	67°	19°	93°	21st ...	63°	16th ...	92	21·94	25	12·43
October ...	82°	66°	16°	96°	16th, 24th	62°	29th ...	91	15·06	18	11·86
November ...	83°	66°	17°	88°	26th ...	62°	26th ...	85	1·71	7	2·26
December ...	80°	66°	14°	87°	1st ...	63°	8th, 9th	90	1·42	3	1·13
Total ...	...	...	...	...	...	...	...	...	83·65	157	76·96
Means ...	88°	67°	21°	94°	...	63°	...	89	...	...	...

TABLE No. 2.

NATIVE FARMING *versus* CONTINUOUS CROPPING EXPERIMENT, 1930.

Plot.	Treatment.	Crop.	Nett yield of tubers in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Y80–96					
Y80	Native Farming ...	Yams	4,648		
81	Continuous Cropping stumped and ridged ...	„		2,888	−1,684
82	Native Farming ...	„	4,496		
83	Continuous Cropping unstumped and ridged	„		3,320	−2,190
84	Native Farming ...	„	6,524		
85	Continuous Cropping stumped and ridged ...	„		2,788	−3,776
86	Native Farming ...	„	6,604		
87	Continuous Cropping unstumped and ridged	„		2,784	−2,934
88	Native Farming ...	„	4,832		
89	Continuous Cropping stumped and ridged ...	„		2,752	−2,686
90	Native Farming ...	„	6,044		
91	Continuous Cropping unstumped and ridged	„		3,112	−2,258
92	Native Farming ...	„	4,696		
93	Continuous Cropping stumped and ridged ...	„		2,308	−2,564
94	Native Farming ...	„	5,048		
95	Continuous Cropping unstumped and ridged	„		2,068	−1,708
96	Native Farming ...	„	2,504		
	Average	...	5,044		...

Each plot $\frac{1}{4}$ acre—planted 15th May—staked 13th June—harvested 10th December and 28th January (1931).

Root—mean—square—difference between neighbouring control plots = 1,465 lb. per acre.

Average yield of 9 plots native farming = 5,044 lb. per acre.
„ difference of 4 plots continuously cropped and stumped −2,677±732.
„ „ „ 4 „ „ „ „ unstumped −2,272±732.
Ridged—experimental plots—7th May. Control plots cleared and burned 24th April.

Weeded 17th July, 15th August, 18th September, 10th October, 13th November.
Cost of cultivation of above experiment 204 man-days per acre.
880 yams planted per plot.

UMUAHIA STATION: FARM ANNUAL REPORT, 1930.

Mr. J. W. Wallace was in charge throughout the year save for the last week when Mr. L. P. Henderson took over.

Rainfall.—The rainfall for the year was below average and the distribution of rain during March was unfortunate. During this month 4.02″ of rain were recorded, 3.21″ of which fell on the two days March 4th and 7th, followed by a drought until the 19th.

This dry period had an adverse effect on the young seedlings of maize which was sown on March 7th-10th.

The rainfall for the critical planting months February to May is given below:—

	1930.	Average 1921–29.
January	1·87	1·04
January–February	3·63	2·20
January–March	7·65	7·85
January–April	14·16	16·57
January–May	22·02	29·52
Total January–December	81·62	99·71

Annual Crops.

Yams.—The average gross yield of yams for the farm was just over two tons (4,504 lb.) per acre as against last year's average of 6,698 lb. per acre. This drop in yield may be attributed almost entirely to the fact that the yams were taken off land which had had an additional years cropping, compared with last year; and further, the average yield for 1929 was raised by the heavy crops obtained from some ten acres grown on land which had been in bush fallow for five years. On practically all the yam plots self-sown calopogonium formed a very strong cover early in the season and periodic weeding had to be resorted to in order to keep it under control.

Early Maize.—The average yield for the farm of 509 lb. dry grain per acre must be considered as disappointing, especially as very good yields were obtained from E1-17 (1,697 lb. per acre) and F10-18 (1,113 lb. per acre)

The low average yield is attributed to the drought conditions prevailing after planting from which the seedlings never really recovered. This adverse effect was particularly noticeable on those plots containing poor sandy soil. The soil in blocks E1-17 and F10-18 is among the best on the farm.

Late Maize.—Owing to continued failure of the crop experiments on late maize have been discontinued.

Groundnuts.—Some 11½ acres of groundnuts were grown. A yield of 923 lb. per acre dry undecorticated nuts was obtained from D1-37 (9¼ acres) which was planted up with seed imported from Ilorin.

Benniseed.—Some eight and half acres of this crop were laid down in the form of preliminary experiments with a view to ascertaining the possibilities of establishing benniseed as a late season crop in place of late maize mentioned above. The first sample of seed obtained from Yandev gave very poor germination.

An additional supply of seed was obtained and though this germinated well, the young plants made no further progress except in one plot in H41-49.

Failure may have been due to the extremely poor soil in which the crop was planted. This suggestion is born out by the fact that the only plot on which a measure of success was obtained (plot 43, H41-49) had been in bush for five years and consisted of fairly good soil. A minor experiment is being devise in 1931 to test this point.

Cover Crops.—Calopogonium again proved itself to be the most satisfactory crop for use as a cover during the latter part of the wet season and for the dry season. That its residual value tended however to be inferior to that of the other green manures grown was indicated by the results obtained in 1929 from the experiment on D1-37. The results of this year's experiment tend to confirm this.

D1-37. Cover Crop Experiment. Groundnut (Ilorin Variety) Test Crop. (Table 2.)

In 1928, as mentioned in last year's report, three cover crops Calopogonium, Centrosema and Crotalaria were tested against Mucuna with a view to comparing their respective merits as to growth and residual effects as green manures. In 1929, early maize was planted as a test crop and this year the experiment was repeated Ilorin variety of groundnuts obtained from Ilorin being use as the test crop.

A very satisfactory yield, for this station, was obtained, but was not so heavy as was expected from the excellent growth and appearance of the crop. On " lifting " the crop it was noted that there was a very large proportion of empty shells.

Significant figures were obtained for groundnuts following Calopogonium and Crotalaria. The yields being respectively less and higher than the controls. The results are somewhat

remarkable in that the Calopogonium afforded an excellent cover and the Crotalaria a very poor one indeed. This would tend to confirm the observation made in last year's report that in spite of the superiority of Calopogonium in affording a good cover its residual effect is, apparently, inferior to that of Mucuna.

With regard to Crotalaria the reverse would appear to be the case: in spite of its extremely poor cover its residual effect would seem to be superior to that of Mucuna. This point however needs confirmation in view of last year's result when the residual value of Crotalaria was shown to be lower, but not significantly so, than that of Mucuna.

	Lb. dry undecorticated nuts per acre.	Odds that the difference is significant.
Average yield of 19 plots following Mucuna ...	923 lb.	—
„ difference of 6 plots following Centrosema ...	+ 5±66	3 : 1
„ „ „ 6 „ „ Calopogonium	−172±66	213 : 1
„ „ „ 6 „ „ Crotalaria ...	+176±66	287 : 1

E1-17. Calopogonium: Time of Digging in Experiment—Early Maize Test Crop. (*See Table 3.*)

This experiment was commenced in 1929 when Calopogonium was planted throughout the block in the early part of the year. On the experimental plots the cover was ridged under in late November, 1929, and on the control plots in early February, 1930.

The test crop of early maize gave an excellent yield off all plots—the figure being a record for the farm. (1,697 lb. dry grain per acre.)

The result obtained indicates that a significantly larger yield follows the cover crop buried at the beginning of the dry season than after that buried at the end of the dry season. These figures however need confirming before any definite conclusion can be arrived at.

	Yield in lb. dry grain per acre.	Odds that the difference is significant.
Average yield of 9 controls dug under in February, 1930	1,595 lb.	—
Average difference of 8 experimental plots dug under in November, 1929	+192±84	92 : 1

N4-28. Yam Variety Experiment. (Table 4.)

The variety experiment laid down on this block in 1929 was repeated this year. As was to be expected the yields obtained were not so high as those of last year, in view of the fact that the land had been in " bush " the five years previous to 1929. The figures were, however, lower than was hoped as a particularly good crop of Calopogonium covered the land throughout the latter part of the wet and the majority of the dry season.

The results obtained this year confirm those obtained last year in the case of Jioku and Accru, but do not confirm those for Oyinta. It should, however, be noted that in the case of Oyinta neither the figures for this nor for last year are significant.

From the results which have been worked out on both nett and gross yields, it will be seen that the figures obtained from nett yields confirm those for the gross yields—

	Yield of tubers per acre.	Odds that difference is significant.
GROSS YIELD.		
Average yield of 13 plots Jike ...	4,090	—
„ difference of 4 plots Accru ...	− 274 ± 250	6 : 1
„ „ „ Jioku ...	+ 1,469 ± 250	33,300 : 1
„ „ „ Oyinta ...	+ 180·5 ± 250	3 : 1
NETT YIELD.		
Average yield of 13 plots Jike ...	2,260	—
„ difference of 4 plots Accru ...	− 330 ± 267	7 : 1
„ „ „ Jioku ...	+ 1,448 ± 267	33,300 : 1
„ „ „ Oyinta ...	+ 69 ± 267	3 : 1

M1-25. Comparison of once farmed land left to bush versus continuously farmed land. Yam Test Crop. (See Table 5.)

This experiment which was commenced in 1929 was concluded this year with a test crop of yams, the continuously cultivated plots having completed their third rotational cycle of yams, maize and groundnuts, in 1929.

An excellent crop of yams was obtained throughout the control plots which was to be expected after five years in bush. The crop given by the experimental plots was, however, disappointingly low. It seems possible that in view of local soil and climatic conditions this rotation is too intensive, and, further, it is considered likely that the inclusion of groundnuts in the rotation may in part be directly responsible for the fall in fertility, as it has since proved a very uncertain crop here, and under the best of conditions serious soil wash is likely to occur between the harvesting of the groundnuts and the establishing of the succeeding cover crop.

Figures have been worked out from both gross and nett yields, the " nett " results emphasising those obtained from the gross yields.

	Yield per acre lb. tubers.	Odds that difference is significant.
GROSS YIELD.		
Average yield of 13 plots once farmed land...	10,828	—
Average difference of 12 plots continuously cultivated	— 6,243 ± 230·5	∞ : 1
NETT YIELD.		
Average yield of 13 plots once farmed	8,674	—
„ difference of 12 plots continuously cultivated	— 6,700 ± 193	∞ : 1

OIL PALMS.

All palms on the farm made very favourable progress—on blocks H21-49 planted in 1923, the number of bearing trees have increased to such a figure that, except on two plots in H41-49, it is fairly safe to prophesy that practically every palm will be in bearing by the end of next year. A number of trees in blocks G31-49 and H51-67 commenced to set fruit during the latter part of the year and it is hoped to start harvesting at the beginning of 1931.

On C1-10 (Deli Oil Palms) self-sown Desmodium came up well and formed a very useful cover, though as mentioned in last year's report it failed during the latter part of the wet season to suppress the more vigorous weeds.

H21-29. Oil Palms in coppiced and cropped land versus Oil Palms in land coppiced only. (*See Table 6.*)

Although the better development of the palms in the cropped plots as compared with those in the adjacent plots is still noticeable the difference is not so marked as in past years. The relative difference in the number of bearing trees under the different treatments has also decreased.

It should be pointed out that the term " Coppiced " is now no longer applicable in its literal meaning.

The stumps have been cut back so frequently that the majority of them have completely rotted away resulting in the " coppiced and cropped " plots now approximating to " stumped and cropped " condition, while the plots described as " coppiced only " are now in grass which is kept short by periodic cutlassing.

H31-39. Oil Palms on coppiced and cropped land versus Oil Palms on stumped and cropped land. (*Table 7.*)

The marked difference in appearance between the control and the experimental plots has gradually decreased each year, and this year the difference is only just discernible.

The remarks relating to the " coppiced and cropped " plots in H21-29 are equally applicable to the similarly treated plots in this block.

In this case so many of the stumps have rotted and disappeared that all plots may now be regarded as " stumped ".

H41-49. Oil Palms in continuously cropped land versus Oil Palms in land once farmed and allowed to revert to bush. (*Table 8.*)

As last year, the palms in the continuously cropped plots are still far superior in all respects to those in the bush plots. In fact, from the point of view of the number of bearing trees per plot the difference is even more marked than last year 76% on the cleared against 3.8% on the bush plots.

A very poor crop of early maize was taken off the continuously cultivated plots. This was followed by late benniseed which germinated fairly well, but made no further progress and ended in a failure.

On plot 43 the bush was cut and burnt and was farmed according to native practice with early maize and benniseed. This plot will be farmed next year with coco-yams and then allowed to revert back to bush.

As a direct result of firing the bush the oil palms on this plot suffered a considerable set back, but recovered later in the year.

It is hoped that next year they will show the benefit derived from the opening up of the bush and the general cultivation received.

Minor Experiments.

Ginger.—A small area ($\frac{1}{10}$ acre) which was planted up with ginger gave a very satisfactory yield of 2,030 lb. gross) dry hands per acre. This yield is considered distinctly encouraging and a further small area will be planted up next season.

TABLE No. 1.

Meteorological Report for 1930.

Umuahia Agricultural Station.

Hour of observation, 9 a.m.

Months.	AIR TEMPERATURE.							Relative humidity Sat. 100.	1930 rainfall in inches.	No. of days.	Average rainfall for 9 years.
	Means.		Range.	Absolute.							
	Max.	Min.		Max.	Date.	Min.	Date.				
January	91	74	17	96	11th ...	66	26th ...	82	1·87	2	1·04
February ...	94	76	18	98	18th ...	70	28th	91	1·76	2	1·16
March	93	74	19	99	29th ...	70	23rd ...	91	4·02	6	5·65
April	91	73	18	96	6th ...	69	11th ...	92	6·51	12	8·72
May	90	72	18	98	23rd ...	66	12th ...	98	7·86	17	12·95
June	87	69	18	98	9th ...	61	17th ...	99	7·90	16	15·03
July	85	65	20	89	19th ...	57	28th ...	92	11·45	17	10·55
August	86	62	24	87	20th ...	58	30th ...	92	14·59	26	11·86
September ...	86	62	24	92	21st ...	59	2nd ...	94	12·37	25	15·42
October	88	63	25	94	26th ...	59	28th ...	93	9·72	14	11·57
November ...	91	61	30	94	17th ...	52	24th ...	89	2·04	4	4·11
December ...	92	66	26	96	16th ...	55	4th ...	89	1·53	4	1·65
Total ...		...	...	...	...	...	...	...	81·62	145	99·71
Means ...	89·5	68·08	21·42	94·75	...	61·83	...	91·83	...	...	...

TABLE No. 2.

D1–37—Cover Crop Experiment—Groundnuts test crop.

Plot.	Late season Treatment.	Crop.	Dry undecorticated nuts per acre in lb.	Increase (+) or decrease (−) compared with mean of adjacent controls.
1	Mucuna	Groundnuts.	680	
2	Centrosema	,,	757	−129
3	Mucuna	,,	1,092	
4	Calopogonium ...	,,	956	−199
5	Mucuna	,,	1,217	
6	Crotalaria	,,	1,633	+413
7	Mucuna	,,	1,222	
8	Centrosema	,,	924	− 99
9	Mucuna	,,	824	
10	Calopogonium ...	,,	758	−123
11	Mucuna	,,	937	
12	Crotalaria	,,	1,264	+380
13	Mucuna	,,	831	
14	Centrosema	,,	858	+ 79
15	Mucuna	,,	727	
16	Calopogonium ...	,,	593	−149
17	Mucuna	,,	756	
18	Crotalaria	,,	899	+137
19	Mucuna	,,	767	
20	Centrosema	,,	700	− 45
21	Mucuna	,,	723	
22	Calopogonium ...	,,	579	−157
23	Mucuna	,,	748	
24	Crotalaria	,,	891	+111
25	Mucuna	,,	812	
26	Centrosema	,,	1,093	+267
27	Mucuna	,,	840	
28	Calopogonium ...	,,	734	−161
29	Mucuna	,,	949	
30	Crotalaria	,,	1,040	+ 49
31	Mucuna	,,	1,033	
32	Centrosema	,,	1,048	− 42
33	Mucuna	,,	1,146	
34	Calopogonium ...	,,	816	−248
35	Mucuna	,,	982	
36	Crotalaria	,,	1,033	− 33
37	Mucuna	,,	1,150	
		Average	923	

Each plot ¼ acre. Ridges 6 feet. Planting distance 2 rows 2 plants per stand 1½ feet staggered.
Groundnuts sown March 5th. Harvested August 26th–29th.
Root—mean—square—difference between adjacent control plots 162 lb. per acre.
Average yield of 19 plots following Mucuna = 923 lb. per acre.
,, difference of 6 plots following Centrosema = +5±66.
,, ,, ,, ,, Calopogonium = −173±66.
,, ,, ,, ,, Crotalaria = +176±66.
Cost of cultivation in man-days per acre = 70.
Percentage decorticated to undecorticated nuts = 52·6%.

TABLE No. 3.

E1–17. Calopogonium Time of Digging in Experiment.

Plot.	Late season Treatment.	Crop.	Yield in lb. dry grain per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
1	Calopogonium dug in February	Maize.	1,632		
2	,, ,, ,, November	,,		1,993	+ 282
3	,, ,, ,, February	,,	1,790		
4	,, ,, ,, November	,,		1,802	+ 56
5	,, ,, ,, February	,,	1,702		
6	,, ,, ,, November	,,		2,085	+ 242
7	,, ,, ,, February	,,	1,984		
8	,, ,, ,, November	,,		1,712	− 53
9	,, ,, ,, February	,,	1,546		
10	,, ,, ,, November	,,		1,866	+ 367
11	,, ,, ,, February	,,	1,451		
12	,, ,, ,, November	,,		1,786	+ 272
13	,, ,, ,, February	,,	1,576		
14	,, ,, ,, November	,,		1,698	+ 156
15	,, ,, ,, February	,,	1,509		
16	,, ,, ,, November	,,		1,546	+ 210
17	,, ,, ,, February	,,	1,163		
	Average	,,	1,595		

Each plot ¼ acre. Ridges 6′. Planting distance 2 rows 1 plant per stand 2′ staggered.

Maize sown March 7th. Harvested July 1st.

Root—mean—square—difference between adjacent control plots = 238 lb. per acre.

Average yield of 9 plots dug in February ... ... = 1,595 lb. per acre

Average difference of 8 plots dug in November ... ... = +192 ±84

Cost cultivation in man-days per acre ... ... = 37·5.

TABLE No. 4.

N4–28. YAM VARIETY EXPERIMENT.

Plot No.		Crop.	Gross yield of tubers in lb. per acre.	Seed rate in lb. tubers per acre.	Nett yield of tubers in lb. per acre.		Increase (+) or Decrease (−) with mean of adjacent controls.
4	Jike ...	Yams.	3,640	1,672	1,968		
5	Accru	,,	3,976	2,016		1,960	− 428
6	Jike ...	,,	4,456	1,648	2,808		
7	Jioku	,,	5,104	1,500		3,604	+1,096
8	Jike ...	,,	3,952	1,744	2,208		
9	Oyinta	,,	4,324	1,780		2,544	+ 372
10	Jike ...	,,	4,144	2,008	2,136		
11	Accru	,,	3,764	1,936		1,828	− 224
12	Jike ...	,,	3,984	2,016	1,968		
13	Jioku	,,	5,936	1,444		3,492	+1,206
14	Jike ...	,,	4,500	1,896	2,604		
15	Oyinta	,,	4,088	2,016		2,072	− 110
16	Jike ...	,,	3,776	2,016	1,760		
17	Accru	,,	3,120	1,848		1,272	− 284
18	Jike ...	,,	3,368	2,016	1,352		
19	Jioku	,,	4,264	1,336		2,924	+1,266
20	Jike ...	,,	3,732	1,768	1,964		
21	Oyinta	,,	4,408	2,016		2,392	+ 84
22	Jike ...	,,	4,416	1,764	2,652		
23	Accru	,,	4,272	1,932		2,340	− 386
24	Jike ...	,,	4,676	1,876	2,800		
25	Jioku	,,	6,972	1,956		5,016	+2,226
26	Jike ...	,,	4,124	1,344	2,780		
27	Oyinta	,,	4,424	1,912		2,512	− 70
28	Jike ...	,,	4,400	2,016	2,384		
			Average ...	...	2,260		

Each plot ¼ acre. Ridges 6′.

Yams planted 4′ staggered on February 5th. Harvested October 24th.

Root—mean—square—difference between adjacent control plots = 533 lb. per acre.

Average yield of 13 control plots Jike = 2,260 lb. per acre.

,, difference of 4 plots Accru = − 331 ±267

,, ,, ,, 4 ,, Jioku = +1,448 ±267

,, ,, ,, 4 ,, Oyinta = + 69 ±267

Cost of cultivation in man-days per acre = 70·9

TABLE No. 5.

M1–25. YAM TEST CROP ON LAND ONCE FARMED AND LEFT TO BUSH VERSUS CONTINUOUS CROPPING.

Plot No.	Treatment.	Crop.	Gross yield in lb. tubers per acre.	Seed rate in lb. tubers per acre.	Nett yield in lb. tubers per acre.		Increase (+) or Decrease (−) compared with mean of adjacent controls.
1	Native practice	Yams	10,032	2,096	7,936		
2	Cont. cultivation	„	4,312	2,112		2,200	− 5,544
3	Native practice	„	9,780	2,228	7,552		
4	Cont. cultivation	„	3,784	1,972		1,812	− 6,032
5	Native practice	„	10,268	2,132	8,136		
6	Cont. cultivation	„	3,380	2,112		1,268	− 7,430
7	Native practice	„	11,400	2,140	9,260		
8	Cont. cultivation	„	4,552	2,148		2,404	− 6,816
9	Native practice	„	11,536	2,356	9,180		
10	Cont. cultivation	„	4,616	2,256		2,360	− 6,620
11	Native practice	„	10,996	2,216	8,780		
12	Cont. cultivation	„	3,472	2,268		1,204	− 6,992
13	Native practice	„	9,628	2,016	7,612		
14	Cont. cultivation	„	5,064	2,128		2,936	− 5,036
15	Native practice	„	10,424	2,092	8,332		
16	Cont. cultivation	„	4,240	2,160		2,080	− 6,380
17	Native practice	„	10,684	2,096	8,588		
18	Cont. cultivation	„	3,684	2,260		1,424	− 7,698
19	Native practice	„	11,788	2,132	9,656		
20	Cont. cultivation	„	4,368	2,132		2,236	− 7,332
21	Native practice	„	11,736	2,256	9,480		
22	Cont. cultivation	„	4,608	2,108		2,500	− 6,944
23	Native practice	„	11,424	2,016	9,408		
24	Cont. cultivation	„	3,716	2,168		1,548	− 7,576
25	Native practice	„	11,072	2,132	8,840		
			Average ...	...	8,674		

Each plot ¼ acre. Ridge 6′.

Yams planted 4′ staggered on February 6th.

„ harvested October 21st.

Root—mean—square—difference between adjacent control plots = 669 lb. per acre.

Average yield of 13 control plots Native Practice = 8,674 lb. per acre.

„ difference of 12 plots Continuous Cultivation = −6,700 ±193

Cost of cultivation in man-days per acre ... ... = −81·5

TABLE No. 6.

H21–29. Oil Palms Yields—January 1st, 1930 to December 31st, 1930.

Plot.	Experiment.	Treatment.	No. of Bunches.	Weight of Bunches.	Weight of Fruit.	Average weight of Bunch.	Average weight of fruit per Bunch.	No. of trees bearing.	
								January.	December.
				lb.	lb.	lb.	lb.		
21	Coppiced and Cropped	Maize and Calopogonium	507	1,989	1,322	3·9	2·6	35	58
23	Coppiced only ...	Bush cut back ...	169	488	328	2·9	1·9	13	33
25	Coppiced and Cropped	Maize and Calopogonium	503	1,764	1,194	3·5	2·4	28	57
27	Coppiced only ...	Bush cut back ...	316	1,005	649	3·2	2·1	15	41
29	Coppiced and Cropped	Maize and Calopogonium	563	2,257	1,583	4·0	2·8	33	55

All plots = 1 acre.

Palms planted 25 ft. × 25 ft.

Number of palms per acre = 65.

TABLE No. 7.

H31–39. Oil Palms Yields—January 1st, 1930 to December 31st, 1930.

Plot.	Experiment.	Treatment.	No. of Bunches.	Weight of Bunches.	Weight of Fruit.	Average weight of Bunch.	Average weight of fruit per Bunch.	No. of trees bearing.	
								January.	December.
			lb.	lb.	lb.	lb.	lb.		
31	Coppiced and Cropped	Maize and Calopogonium ...	650	3,506	2,481	5·4	3·8	53	60
33	Stumped and Cropped	Maize and Calopogonium ...	624	4,319	2,890	7·0	4·6	51	62
35	Coppiced and Cropped	Maize and Calopogonium ...	627	2,703	1,966	4·3	3·1	47	57
37	Stumped and Cropped	Maize and Calopogonium ...	575	3,274	2,119	5·7	3·7	49	58
39	Coppiced and Cropped	Maize and Calopogonium ...	579	2,134	1,446	3·7	2·5	43	56

All plots = 1 acre.

Palms planted 25 ft. × 25 ft.

Number of palms per acre = 65.

TABLE No. 8.

H41–49. Oil Palms Yields—January 1st, 1930 to December 31st, 1930.

Plot.	Experiment.	Treatment.	No. of Bunches.	Weight of Bunches.	Weight of Fruit.	Average Weight of Bunch.	Average weight of fruit per Bunch.	No. of trees bearing.	
								January.	December.
				lb.	lb.	lb.	lb.		
41	Continuous Cropping ...	Maize Benniseed Mucuna ...	483	2,552	1,807	5·3	3·7	34	57
43	Native Practice	Maize Benniseed	2	7	5	3·5	2·5	2	2
45	Continuous Cropping ...	Maize Benniseed Mucuna ...	461	1,886	1,362	4·0	3·0	19	50
47	Bush	Bush	9	41	29	4·6	3·2	0	3
49	Continuous Cropping ...	Maize Benniseed Mucuna ...	362	1,330	877	3·7	2·4	15	42

All plots = 1 acre.

Palms planted 25 ft. × 25 ft.

Number of palms per acre = 65.

ANNUAL BULLETIN REPORT, 1930, SAMARU AGRICULTURAL STATION, ZARIA, NORTHERN PROVINCES.

The following officers were in charge of the station during the year:—

Mr. E. W. Leach, B.SC. from 1st January to 11th April.
,, K. D. R. Davis, M.A., from 11th April to 30th April.
,, R. B. Shorter from 30th April to 31st December.

Introduction.

When this station was started in 1923, of the 700 acres comprising the estate 100 acres were tilled during that year, all of which were cultivated by hand labour.

The acreage of arable land has been gradually increased, and now 133 acres are under cultivation at Samaru and 33 acres at Bomo. The introduction of cattle-drawn implements in 1928 has reduced the cost of cultivation very considerably, and during the year only two and a half acres were cultivated entirely by hand labour.

The season under review was not very favourable. The total rainfall, 41.25 inches (Table No. 1), was below the average and quite abnormal. The fall of rain in May and April was normal. This was followed by a severe drought in June and a partial drought in July. There was a record maximum fall in August and after the middle of September no appreciable fall was recorded.

These facts, coupled with the attacks of locusts seriously affected the yields of all crops.

General.

The year has been remarkable in that it has witnessed a steady and growing interest on the part of the native farmer in mixed farming, also an improvement in the standard of the work done by the ploughs on our own farm. Five more farmers started mixed farming during the year and there is every reason to expect that as many as 20 or 30 will be using cattle on their farms before the end of 1931. The locally made wooden ploughs have been still further improved and are now so satisfactory that we felt justified in testing a light steel ridging plough (Ransome's D.Y. 3). This plough can be sold to the native at the very reasonable price of £3 11s. and if it proves satisfactory will probably be preferred to the cheaper wooden plough by the more wealthy farmers.

Some tentative experiments to test the effect of work and feeding on the milk yield of cows were started during the year and are still in progress. The results obtained so far, though interesting, are not sufficient to justify any comment, but the experiments will be continued for another year.

Experiments in connection with the management of grass-land have also been started. Over twenty acres of pastureland have been fenced and the effect on the grasses of close grazing and early burning is being investigated. The Agricultural Chemists are carrying out analyses of samples of different cuts of grass, made into hay and silage, and are making monthly analyses throughout the year of the grass in the plots grazed closely. There is every indication that grass silage will in the future be of great assistance to the settled cattle owner during the dry season.

On the experimental farm further tests of the effects of applications of farm-yard manure to different crops have been carried out. A small experiment was also laid out on a spare piece of land to see whether the effect of F.Y.M., was entirely due to the fact that it increases the supply of humus in the soil. The various treatments were F.Y.M. kraaling and grass, and grass alone, and these were compared with unmanured plots. Lack of land prevented the experiment being laid out in such a way that the results were capable of statistical treatment but it was very obvious even to the eye that the plots manured with F.Y.M. were greatly superior to those manured with grass only. The latter, in fact, did not yield as well as the unmanured plots.

Farm-yard Manure on Cotton Experiment.—Table 2.

As in previous years this experiment was continued to ascertain the effect of an annual dressing of one ton manure per acre on the yield of cotton.

	Lb. of seed cotton per acre.	Odds that the difference is significant.
Average yield of 7 plots without manure ...	178	—
Average difference of 6 plots with manure as compared wit those without	+76·5±32·4	160 : 1

Although, like the rest of the cotton on the farm, the yield from this block was small, the effect of the manure was very marked. Not only did it affect the final yield but all through the growing season the cotton on the manured plots was more vigorous than on the unmanured plots and the difference could be easily detected by the eye.

FARM-YARD MANURE ON GROUNDNUTS EXPERIMENT.—Table 3.

To test the value of three tons per acre of farm-yard manure applied to groundnuts.

	Lb. per acre of shelled nuts.	Odds that the difference is significant.
Average yield of 7 plots without manure ...	389	—
Average difference of 6 plots with manure as compared with those without	+220·7±20·1	∞ : 1

It had always been rather assumed that there was little point in applying manure to the groundnut crop. Groundnuts will thrive on such poor soil and give such comparatively good yields that it was thought doubtful whether the increased yield which manure might cause would be worth while. The increase in yield due to the manure was in fact much greater than had been expected and shows that the groundnut crop like the cereals readily responds to dressings of F.Y.M.

RATE OF MANURING EXPERIMENT.—Table 4.

Commenced in 1929, this experiment was carried out to test whether it was more advantageous to apply to guinea-corn small dressings of farm-yard manure frequently or larger dressings at longer intervals.

	Lb. of threshed grain per acre.	Odds that the difference is significant.
Average yield of 13 plots without manure ...	166	—
Average difference of 4 plots manured with 1 ton per acre each year	+200±31·2	33,000 : 1
Average difference of 4 plots manured with 2 tons per acre every second year... ...	+ 44±31·2	14 : 1
Average difference of 4 plots manured with 3 tons per acre every third year	+ 60±31·2	34 : 1

At the above rates of application each treatment plot at the end of six years would have received six tons per acre. Only the plots receiving one ton annually received and manure this year. Last year when all plots were manured the yields were more or less proportional to the amount of manure applied but this year the treatment plots which remained unmanured only gave a comparatively small increase over the controls. The plots receiving an annual dressing however showed an even greater increase than they did last year. This experiment shows so conclusively that " little and often " is the best method of manuring guinea-corn that it is to be discontinued.

COTTON STRAIN TEST.—Table 5.

In this experiment strain D was tested against ordinary Allen cotton from Zaria Ginnery.

	Lb. per acre of seed cotton.	Odds that the difference is significant.
Average yield of 16 plots sown with ordinary cotton	97	—
Average difference of 15 plots sown with Strain D as compared with plots sown with ordinary cotton	+ 14±9.9	14 : 1

In spite of the fact that strain " D " was attacked by jassids it yielded slightly better than the ordinary commercial cotton, but the yields were so low over the whole block that the results are of no great value especially as it has now been decided to discontinue the multiplication of strain " D ". The Botanist has several other strains which appear to be as good as strain " D " and are more or less jassid resistant. These are to be fully tested and the best of them will be multiplied for general distribution in the place of Strain " D ".

BOTANISTS' STRAINS OF GUINEA-CORN TEST.—Table 6.

This experiment was carried out in two parts as one of the strains was a yellow-seeded variety and this was tested against the ordinary yellow-seeded variety. The other three strains, being of the white-seeded variety were tested against ordinary white-seeded variety.

	Lb. per acre of threshed grain.	Odds that the difference is significant.
Average yield of 5 plots planted with ordinary farm yellow-seeded variety (Kaura)	574	—
Average difference of 4 plots planted with Botanist's strain of Kaura as compared with ordinary farm Kaura	− 31·5±58·3	Less than 3 : 1
Average yield of 12 plots planted with ordinary farm white-seeded variety (Farafara)	571	—
Average difference of 3 plots planted with Botanist's strain 6 as compared with ordinary farm Farafara	+214·7±21·1	∝
Average difference of 4 plots planted with Botanist's Strain 7 as compared with ordinary farm Farafara	+ 37±18·25	43 : 1
Average difference of 4 plots planted with Botanist's Strain 9 as compared with ordinary farm Farafara	+134·5±18·25	∝

These results clearly prove the marked superiority of strains 7 and 9 over the ordinary strains.

Groundnut Variety Test.—Table 7.

	Lb. per acre of shelled nuts.	Odds that the difference is significant.
Average yield of 16 plots sown with Mache Atsugane	427	—
Average difference of 3 plots sown with Basse	−111±25	33,000 : 1
Average difference of 3 plots sown with Ceylon	− 93±25	33,000 : 1
Average difference of 3 plots sown with Philippine Pink	− 83±25	4,350 : 1
Average difference of 3 plots sown with Damberta	+ 61±25	160 : 1
Average difference of 3 plots sown with Philippine White	−152±25	Over 33,000 : 1

The results of the experiment show that none of the exotic varieties have proved themselves to be better yielders than Mache Atsugane which is the local upright type of groundnut. This is not surprising as the groundnut is a crop of light sandy soils, and the soil at Samaru is decidedly heavy and apt to be water-logged. Mache Atsugane is a local type which has adapted itself to these conditions, and the finding of a better variety to replace it will probably be a difficult task. At Kano with its typical groundnut soil some of the exotic varieties, and in particular Philippine White, did very well indeed and were superior to the local type. It is, however, interesting to note that Philippine Pink matured 25 days earlier than the others. In consequence it was much the easiest and least expensive to harvest as the ground at that time was still moist. The Mache Atsugane type gave the highest yield of haulm.

Cross Cultivation Experiment.—Table 8.

By this experiment it was intended to find out whether by cultivating between the plants across the ridges the cost of labour in hand-hoeing could be appreciably reduced and whether the implements would cause any damage to the plants.

Difficulties arose over the question of costs which made the figures unreliable but the results showed that cross cultivation did no harm whatever to the plants, the yield from both treatments being practically the same.

Cotton Strain Tests.—Table 9

	Lb. per acre of seed cotton.	Odds that the difference is significant.
Average yield of 7 plots sown with Strain D.	200	—
Average difference of 8 plots sown with Strain G.	− 53±14	4,350 : 1
Average difference of 8 plots sown with Strain J.	0±14	Nil.

Since this experiment was started strain D has proved non-resistant to jassids and strain J, although as good a yielder as strain D has a very poor ginning percentage Therefore all three strains are being discarded.

COTTON VARIETY TEST.—Table 10.

	Lb. of seed per acre.	Odds that the difference is significant.
Average yield of 17 plots sown with Zaria Ginnery Allen Grade 1	286	—
Average difference of 4 plots sown with Acala	− 72·5±28·7	33,000 : 1
Average difference of 4 plots sown with U4	+ 16 ±28·7	3 : 1
Average difference of 4 plots sown with Meso-white	− 89 ±28·7	740 : 1
Average difference of 4 plots sown with H21	− 50 ±28·7	21 : 1

Acala is a large bolled Texas cotton which has done well in America, but it proved to be very susceptible to jassid attack.

Meso-white, an American "Webber" cotton grown in Mesopotamia is also non-resistant to jassids.

U4 is a cotton bred by the Empire Cotton Growing Corporation in South Africa and is a jassid resister.

H21 is a Hartesville selection from America; both it and U4 are being given a further trial next season.

POULTRY.

As in previous years a small stock of Rhode Island Reds has been kept. New blood has been introduced recently from England and the hens are being trap-nested. The demand for eggs has been small but that for stock has exceeded the supply.

CATTLE.—Tables 14 and 15.

Jetsam, No. 5, the first calf reared by the pail in 1926 has been used as one of the stock bulls during the year. This bull was out of cow No. 26 and the first of his progeny was calved this year out of a heifer of our own breeding which was born at Samaru in 1927. She calved in September 1930 and in seven months has given close on 2,000 lb. of milk.

The cows' yields have been recorded daily and butter fat tests taken monthly but as these are incomplete it has not been possible to include them in this report. All calves have been weighed weekly from birth to twelve months old and the figures are

being graphed. Up to June the calves were fed on gruel but since then dry feeding has been substituted and has been found to be more satisfactory.

The cattle have suffered badly from streptothricosis during the rains. Several died and several more had to be slaughtered. Dipping was started towards the end of the year and it is hoped that this will keep this disease in check in future.

TABLE No. 1.

NEW EXHAUSTIBILITY EXPERIMENT.

YIELDS—1930-31.

	Crop.	Pounds per acre of unthreshed, unshelled, etc., produce.
Block C 1	Guinea corn	970
2	Groundnuts	612
3	Guinea corn	1,166
4	Cotton	166
5	Guinea corn	1,020
6	Groundnuts	532
7	Guinea corn	822
8	Cotton	140
9	Guinea corn	1,020
10	Groundnuts	582
11	Guinea corn	870
12	Cotton	134
13	Guinea corn	768
14	Groundnuts	438
15	Guinea corn	726
16	Cotton	192
17	Guinea corn	884
18	Groundnuts	520
19	Guinea corn	978
20	Cotton	238
21	Guinea corn	918
22	Groundnuts	540
23	Guinea corn	922
24	Cotton	235
25	Guinea corn	975
26	Groundnuts	550
27	Guinea corn	792
28	Cotton	176
29	Guinea corn	787
30	Groundnuts	546
31	Guinea corn	978
32	Cotton	160
33	Guinea corn	984

TABLE No. 2.

NEW FODDER CROP EXPERIMENT.

YIELDS, 1930-31.

Block.	*Guinea-corn.* Pounds per acre of unthreshed grain.	*Mucuna.* Pounds per acre of partially cured hay.	*Millet—8 rows.* Pounds per acre of unthreshed grain.	
D 51	524		886	
52		1,430		972
53	406		880	
54		1,512		948
55	418		1,062	
56		1,440		928
57	382		860	
58		1,552		882
59	504		824	
60		1,260		874
61	418		738	
62		1,540		708
63	368		740	
64		1,236		710
65	380		620	
66	338		492	

TABLE No. 3.

PERMANENT DEMONSTRATION PLOTS.

YIELDS, 1930-31.

	Crop.	Pounds per acre of unthreshed, unshelled, etc. produce.
E 1	Cotton	142
2	„	178
3	„	124
4	„	146
5	„	120
6	Groundnuts (mayyado)	842
7	„	808
8	„	838
9	„	748
10	„	616
11	Guinea-corn	720
12	„	494
13	„	526
14	„	530
15	„	564
16	Millet (8 rows)	454
	Botanist's variety beans	—
17	Millet (8 rows)	460
	Botanist's variety beans	—
18	Millet (8 rows)	420
	Botanist's variety beans	—
19	Millet (8 rows)	594
	Botanist's variety beans	—
20	Millet (8 rows)	530
	Yellow Soya bean	118

TABLE No. 4.

Farm-yard Manure *versus* Kraaling Experiment.

Block and Plot.	Treatment.	Pounds per acre of threshed grain.		Difference from means of adjacent controls 100, 200, 300, 400.
		Control Plots.	Treatment Plots.	
E 34	400 C.N. Kraaling ...	443		
35	100 C.N. F.Y.M. ...		436	−17·5
36	400 Kraaling ...	464		
37	200 C.N. F.Y.M. ...		486	+44
38	400 Kraaling ...	420		
39	300 C.N. F.Y.M. ...		492	+77
40	400 Kraaling ...	410		
41	400		533	+125
42		406		
43	100		490	+31
44		512		
45	200		490	−14
46		496		
47	300		476	+32
48		392		
49	400		494	+90
50		416		
51	100		446	+88
52		300		
53	200		453	+120·5
54		365		
55	300		324	−16·5
56		316		
57	400		347	+17
58		344		
59	100		392	+49·5
60		341		
61	200		415	−35
62		496		
63	300		563	+55
64		520		
65	400		594	−23
66	400 Kraaling ...	714		
	Average	432·6	Averages	+37·75
				+36·75
				+37
				+52·25

Root-mean—square—difference between neighbouring controls=164·6 lb. per acre.

Standard Error=82·3 lb. per acre. Odds less than 3 : 1.

TABLE No. 5.

Groundnuts Interplanted with Bulrush Millet Experiment.

Plot.	Crop.	Treatment.	Pounds per acre of Shelled nuts.		Increase (+) decrease (−) from yield of adjacent controls.	Pounds per acre of unshelled Millet.
			Control Plots.	Treatment. Plots.		
B 35	Groundnuts	6 rows millet	106			230
36	„	No „ „		121	+10	
37	„	6 „ „	116			118
38	„	9 „ „		142	+6	220
39	„	6 „ „	157			206
40	„	3 „ „		181	+25	98
41	„	6 „ „	155			102
42	„	No „ „		218	+55	—
43	„	6 „ „	172			102
44	„	9 „ „		150	−13	80
45	„	6 „ „	155			68
46	„	3 „ „		172	−1	36
47	„	6 „ „	192			56
48	„	No „ „		199	+9	—
49	„	6 „ „	188			116
50	„	9 „ „		185	+6	130
51	„	6 „ „	171			88
52	„	3 „ „		192	+14	68
53	„	6 „ „	185			80
54	„	No „ „		210	+22	—
55	„	6 „ „	192			114
56	„	9 „ „		201	+25	106
57	„	6 „ „	160			32
58	„	3 „ „		206	+40	42
59	„	6 „ „	172			62
60	„	No „ „		201	+24	—
61	„	6 „ „	183			20
62	„	9 „ „		176	+18	22
63	„	6 „ „	134			34
64	„	3 „ „		142	−33	82
65	„	6 „ „	216			258
66	„	Non-experimental	245			376
		Average ...	165	...	...	...

Variety sown—Mache atsugane.

Each plot ¼ acre each—sown June 15th, 1930—harvested November 25th, 1930 –Plants 1′ apart on 2′ 6″ ridges—Millet sown April 19th, 1930—harvested August 20th, 1930. Width of plot 33′.

TABLE No. 5—continued.

Increase (+) or decrease (−) of plots sown with no millet as compared with plots sown with 6 rows of millet.	Increase (+) or decrease (−) of plots sown with 9 rows of millet as compared with plots sown with 6 rows.	Increase (+) or decrease (−) of plots sown with 3 rows of millet as compared with plots sown with 6 rows.
+ 10	+ 6	+ 25
+ 55	+ 13	− 1
+ 9	+ 6	+ 14
+ 22	+ 25	+ 40
+ 24	+ 18	− 33
Average + 24 ± 14 lb. per acre.	Average + 8 ± 14 lb. per acre.	Average + 9 ± 14 lb. per acre

Root—mean —square—difference between neighbouring control plots = 31·3 lb. per acre.

Cost of cultivation in man-days per acre: —Groundnuts = 49·1

Millet = 21·0

NOTES :—Plots 40 and 45 had germination percentages of 60–70% for the Millet crop.

Plots 44, 46, 52, 57, 58, 62 and 63 under 90%.

Plot 64 had a germination percentage of only 36% for the Millet crop.

The Groundnut crop planted late suffered from drought in June and July.

The first sowing of Millet germinated very badly.

GROUNDNUTS INTERPLANTED WITH BULRUSH MILLET.

The object of this experiment was to ascertain the effect of millet on interplanted groundnuts but the growth of both millet and groundnuts was so poor that the result cannot be regarded as reliable.

	Pounds per acre of shelled nuts.	Odds that the difference is significant.
Average yield of 16 plots interplanted with 6 rows of bulrush millet	165	—
Average difference of 5 plots without millet	+24±14	14:1
Average difference of 5 plots interplanted with 9 rows of bulrush millet as compared with plots planted with 6 rows	+ 8±14	Nil.
Average difference of 5 plots interplanted with 3 rows of bulrush millet as compared with plots planted with 3 rows	+ 9±14	Less than 3:1

TABLE No. 6.

MUCUNA BEANS INTERPLANTED WITH MILLET EXPERIMENT.

Plot.	Crop.	Treatment.	Pounds per acre of cut fodder.		Increase (+) or decrease (−) from yields of adjacent controls.	Pounds per acre of unthreshed Millet.
			Control Plots	Treatment Plots.		
B 69	Mucuna beans	6 rows of millet	1,380			418
70	,,	3 ,, ,,		1,440	+ 72	530
71	,,	6 ,, ,,	1,356			694
72	,,	9 ,, ,,		1,848	+358	698
73	,,	6 ,, ,,	1,624			622
74	,,	3 ,, ,,		2,044	+488	348
75	,,	6 ,, ,,	1,488			736
76	,,	9 ,, ,,		1,376	− 52	706
77	,,	6 ,, ,,	1,368			700
78	,,	3 ,, ,,		1,932	+548	368
79	,,	6 ,, ,,	1,400			746
80	,,	9 ,, ,,		1,876	+624	822
81	,,	6 ,, ,,	1,104			712
82	,,	3 ,, ,,		1,104	− 72	292
83	,,	6 ,, ,,	1,248			728
84	,,	9 ,, ,,		1,204	+ 4	684
85	,,	6 ,, ,,	1,152			658
86	,,	3 ,, ,,		1,656	+228	398
87	,,	6 ,, ,,	1,704			724
88	,,	9 ,, ,,		1,414	−180	796
89	,,	6 ,, ,,	1,484			652
90	,,	3 ,, ,,		1,344	−154	346
91	,,	6 ,, ,,	1,512			566
92	,,	9 ,, ,,		960	−528	518
93	,,	6 ,, ,,	1,464			490
94	,,	3 ,, ,,		1,608	+486	250
95	,,	6 ,, ,,	780			484
96	,,	9 ,, ,,		1,144	+250	462
97	,,	6 ,, ,,	1,008			496
98	,,	3 ,, ,,		1,872	+538	402
99	,,	6 ,, ,,	1,660			966
100	,,	Non-experimental				1,388
		Average ...	...	...	...	...

Variety sown—Nyasaland CN/54 (Stizolobium nireum)

Each plot ¼ each—sown June 19th, 1930—harvested November 3rd, 1930—Plants staggered 18" apart on ridge between stands of millet on 2' 6" ridges—

Millet sown April 19th, 1930—harvested August 21st, 1930.

Width of plot 33'.

TABLE No. 6—continued.

Increase (+) or decrease (−) of plots sown with 9 rows of millet as compared with plots sown with 6 rows.	Increase (+) or decrease (−) of plots sown with 3 rows of millet as compared with plots sown with 6 rows.
+ 358	+ 72
− 52	+ 488
+ 624	+ 548
+ 4	− 72
− 180	+ 228
− 528	− 154
+ 250	+ 486
	+ 538
Average + 68 ± 107 lb. per acre.	Average + 267 ± 114 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 318·9 lb. per acre.
Cost of cultivation in man-days per acre :—
Mucuna beans cut for fodder = 40·1
Millet interplanted ... = 9·9

TABLE No. 7.

Groundnut Spacing Experiment.

Plot.	Crop.	Treatment.	Pounds per acre of shelled nuts.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control plots.	Treatment plots.	
D 32	Groundnuts	12 inches apart	351		
33	,,	9 ,,		319	+15·5
34	,,	12 ,,	256		
35	,,	9 ,,		292	+29
36	,,	12 ,,	270		
37	,,	9 ,,		325	+66·5
38	,,	12 ,,	247		
39	,,	9 ,,		288	+21·5
40	,,	12 ,,	286		
41	,,	9 ,,		287	+ 4·5
42	,,	12 ,,	279		
43	,,	9 ,,		296	− 8·5
44	,,	12 ,,	330		
45	,,	9 ,,		338	+11·5
46	,,	12 ,,	323		
47	,,	9 ,,		406	+90·5
48	,,	12 ,,	308		
49	,,	12 ,,	282		
	Average ...	...	293		+29

Each plot ¼ acre—variety sown—Mache atsugane—on June 17th, 1930—harvested November 15th, 1930 –on 2 feet 6 inches ridges.
Increase (+) or decrease (−) of plots sown with Groundnuts 9 inches apart on the ridge as compared with plots sown with Groundnuts 12 inches apart.
Average + 29 ± 15 lb. per acre.
Root—mean—square—difference between neighbouring control plots = 42·1 lb. per acre.
Cost of cultivation in man-days per acre = 69·3.

TABLE No. 1.

RAINFALL—SAMARU, 1930.

Month.	Inches of rain.	Number of days on which rain fell.	Average rainfall at Samaru, 1924–29.
January	...	...	...
February	...	...	·003
March	0·02	1	·825
April	1·33	5	1·335
May	4·55	12	4·795
June	3·53	10	7·508
July	8·96	19	10·221
August	15·34	28	11·993
September	7·34	19	9·128
October	0·18	3	2·233
November	...	...	·067
December	...	...	...
Totals	41·25	97	48·108

Note:—0·02 inches fell in February, 1928. 3·53 inches in June and 15·34 inches in August are the lowest and highest falls recorded for those months.

TABLE No. 2.

Farm-yard Manure on Cotton Experiment.

Plot.	Crop.	Treatment.	Pounds per acre of seed cotton.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control plots.	Treatment plots.	
A 1	Allen Cotton	No Manure ...	58		
2	„	1 ton F. Y. M.		202	+ 76
3	„	No Manure ...	194		
4	„	1 ton F. Y. M.		290	+100
5	„	No Manure ...	186		
6	„	1 ton F. Y. M.		214	+ 45
7	„	No Manure ...	152		
8	„	1 ton F. Y. M.		258	+ 56
9	„	No Manure ...	252		
10	„	1 ton F. Y. M.		330	+ 79
11	„	No Manure ...	250		
12	„	1 ton F. Y. M.		304	+103
13	„	No Manure ...	152		
		Average	178		+ 76·5

Variety sown—Allen.

Each plot $\frac{1}{4}$ acre—sown July 10th, 1930 harvested December 27th, 1930 to February 2nd, 1930—Plants 12 inches apart on 2 feet 6 inches ridges.

Average increase (+) or decrease (−) of yield of manured plots as compared with unmanured plots= +76·5±32·4.

Root—mean—square—difference between neighbouring control plots=81.

Cost of cultivation in man-days per acre=51·6.

TABLE No. 3.

FARM-YARD MANURE ON GROUNDNUTS EXPERIMENT.

Plot.	Crop.	Treatment.	Pounds per acre of shelled nuts.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control plots.	Treatment plots.	
A 14	Groundnuts ...	No Manure ...	404		
15	„ ...	3 tons F. Y. M. ...		576	+ 176
16	„ ...	No Manure ...	396		
17	„ ...	3 tons F. Y. M. ...		630	+ 208
18	„ ...	No Manure ...	448		
19	„ ...	3 tons F. Y. M. ...		648	+ 242
20	„ ...	No Manure ...	364		
21	„ ...	3 tons F. Y. M. ...		582	+ 198
22	„ ...	No Manure ...	404		
23	„ ...	3 tons F. Y. M. ...		648	+ 272
24	„ ...	No Manure ...	348		
25	„ ...	3 tons F. Y. M. ...		580	+ 228
26	„ ...	No Manure ...	356		
		Average	389		+ 221

Variety sown—Mache atsugane.

Each plot $\frac{1}{4}$ acre—sown June 7th, 1930—harvested October 23rd, 1930 to November 7th, 1930—plants 12 inches apart on 2 feet 6 inches ridges.

Average increase (+) or decrease (−) of yield of manured plots as compared with unmanured plots= +221 ± 20.

Root—mean—square—difference between neighbouring control plots= 49·4.

Cost of cultivation in man-days per acre = 88·8.

TABLE No. 4.

RATE OF MANURING EXPERIMENT.

Plot.	Crop.	Treatment.	Pounds per acre of threshed grain.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control plots.	Treatment plots.	
A 41	Guinea-corn.	No Manure	202		
42	,,	F.Y.M. 1 ton per acre each year ...		412	+ 226·5
43	,,	No Manure	169		
44	,,	F.Y.M. 2 tons per acre second year		237	+ 55·5
45	,,	No Manure	194		
46	,,	F.Y.M. 3 tons per acre every third year		294	+ 68·5
47	,,	No Manure	257		
48	,,	F.Y.M. 1 ton per acre each year ...		554	+ 329
49	,,	No Manure	193		
50	,,	F.Y.M. 2 tons per acre every second year		224	+ 53
51	,,	No Manure	149		
52	,,	F.Y.M. 3 tons per acre every third year		152	+ 18
53	,,	No Manure	119		
54	,,	F.Y.M. 1 ton per acre each year ...		312	+ 127
55	,,	No Manure	251		
56	,,	F.Y.M. 2 tons per acre every second year		158	− 36
57	,,	No Manure	137		
58	,,	F.Y.M. 3 tons per acre every third year		221	+ 69·5
59	,,	No Manure	166		
60	,,	F.Y.M. 1 ton per acre each year ...		268	+ 117
61	,,	No Manure	136		
62	,,	F.Y.M. 2 tons per acre every second year		228	+ 105
63	,,	No Manure	110		
64	,,	F.Y.M. 3 tons per acre every third year		178	+ 85·5
65	,,	...	75		
		Average	166	...	...

Variety sown—Yellow seeded—Kaura (Hausa).

Each plot ¼ acre—sown May 14th, 1930—harvested November 28th, 1930—plants 4′ apart on 2′ 6″ ridges—manure applied to 1 ton per acre plots May 5th, 1930.

TABLE No. 4—continued.

Increase (+) or decrease (−) of plots manured with 1 ton per acre of f.y.m. each year as compared with unmanured plots.	Increase (+) or decrease (−) of plots manured with 2 tons per acre of f.y.m. every second year as compared with unmanured plots
+ 226·5	+ 55·5
+ 329	+ 53
+ 127	− 36
+ 117	+105
Average + 200 ± 31·2 lb per acre.	Average + 44 ± 31·2 lb per acre.

Increase (+) or decrease (−) of plots manured with 3 tons per acre of f.y.m. every third year as compared with unmanured plots.
+ 68·5
+ 18
+ 69·5
+ 85·5
Average + 60 ± 31·2 lb per acre.

Root—mean—square—difference between neighbouring control plots = 62·4 lb. per acre.

Cost of cultivation in man-days per acre = 40.3.

„ applying 1 ton of f.y.m. per acre = 5·3.

NOTE.—All plots suffered badly from depredations by locusts and to a certain extent from waterlogging.

TABLE No. 5.

Cotton Strain Test—Zaria Ordinary *versus* Strain D.

Plot.	Crop.	Treatment.	Pounds per acre of seed cotton.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control plots.	Treatment plots.	
C 35	Cotton	Zaria ordinary	246		
36	„	Strain D		232	+ 25
37	„	Zaria ordinary	168		
38	„	Strain D		136	+ 4
39	„	Zaria ordinary	96		
40	„	Strain D		102	+ 3
41	„	Zaria ordinary	102		
42	„	Strain D		118	+ 21
43	„	Zaria ordinary	92		
44	„	Strain D		126	+ 30
45	„	Zaria ordinary	100		
46	„	Strain D		104	+ 10
47	„	Zaria ordinary	88		
48	„	Strain D		104	+ 24
49	„	Zaria ordinary	72		
50	„	Strain D		72	+ 6
51	„	Zaria ordinary	60		
52	„	Strain D		36	− 10
53	„	Zaria ordinary	32		
54	„	Strain D		86	+ 18
55	„	Zaria ordinary	104		
56	„	Strain D		68	− 9
57	„	Zaria ordinary	50		
58	„	Strain D		46	− 14
59	„	Zaria ordinary	70		
60	„	Strain D		114	+ 47
61	„	Zaria ordinary	64		
62	„	Strain D		94	+ 28
63	„	Zaria ordinary	68		
64	„	Strain D		130	+ 24
65	„	Zaria ordinary	144		
66	„	Non-experimental ...	200		
		Average ...	97	...	+ 14

Variety sown—Allen.

Each plot $\frac{1}{4}$ acre each—sown July 12th, 1930—harvested December 29th, 1930—February 4th, 1931—plants 1″ apart on 2′ 6″ ridges.

Increase (+) or decrease (−) of plots sown with Strain D as compared with plots sown with Zaria ordinary.

Average + 14 ± 9·9 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 38·4 lb. per acre.

Cost of cultivation in man-days per acre = 36·4.

TABLE No. 6.

GUINEA-CORN STRAINS TEST—BOTANIST'S STRAINS *versus* FARM.

(*a*) Yellow seeded variety—Kaura (Hausa) Botanist's Strains *versus* Farm Ordinary.

Plot.	Crop.	Treatment.	Pounds per acre of threshed Grain.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control plots.	Treatment plots.	
B 69	Guinea-corn	Farm Ordinary ...	688		
70	„	Botanist's Strain ...		498	− 126
71	„	Farm Ordinary ...	560		
72	„	Botanist's Strain ...		598	+ 28·5
73	„	Farm Ordinary ...	579		
74	„	Botanist's Strain ...		532	− 65·5
75	„	Farm Ordinary ...	616		
76	„	Botanist's Strain ...		558	+ 37
77	„	Farm Ordinary ...	426		
		Average ...	574	...	− 31·5

Data same as for second part of test.

Increase (+) or decrease (−) of plots sown with Botanist's Strain of Guinea-corn as compared with ordinary farm Guinea-corn.

Average −31·5 ± 58·3 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 116·6 lb. per acre.

TABLE No. 6—continued.

(*b*) WHITE SEEDED VARIETY (BLACK GLUMES)—FARAFARA (HAUSA) FARM ORDINARY *versus* BOTANIST'S STRAINS 6, 7 AND 9.

Plot.	Crop.	Treatment.	Pounds per acre of threshed Grain.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control plots.	Treatment plots.	
B 78	Guinea-corn	Farm Ordinary ...	564		
79	,,	Strain 9		698	+ 88
80	,,	Farm Ordinary ...	656		
81	,,	Strain 7		683	+ 22
82	,,	Farm Ordinary ...	666		
83	,,	Strain 6		860	+ 206
84	,,	Farm Ordinary ...	642		
85	,,	Strain 9		763	+ 136
86	,,	Farm Ordinary ...	612		
87	,,	Strain 7		611	+ 21
88	,,	Farm Ordinary ...	568		
89	,,	Strain 6		744	+ 184
90	,,	Farm Ordinary ...	552		
91	,,	Strain 9		695	+ 153
92	,,	Farm Ordinary ...	532		
93	,,	Strain 7		558	+ 40
94	,,	Farm Ordinary ...	504		
95	,,	Strain 6		755	+ 254
96	,,	Farm Ordinary ...	498		
97	,,	Strain 9		676	+ 161
98	,,	Farm Ordinary ...	532		
99	,,	Strain 7		595	+ 65
100	,,	Farm Ordinary ...	528		
		Average ...	571	...	...

Each plot ¼ acre—sown May 15th, 1930—harvested December 1st, 1930—plants 4' apart on 2' 6" ridges.

Increase (+) or decrease (−) of plots sown with Strain 9 as compared with plots sown with ordinary farm Guinea-corn.	Increase (+) or decrease (−) of plots sown with Strain 7 as compared with plots sown with ordinary farm Guinea-corn.	Increase (+) or decrease (−) of plots sown with Strain 6 as compared with plots sown with ordinary farm Guinea-corn.
+ 88	+ 22	--
+136	+ 21	+206
+153	+ 40	+184
+161	+ 65	+254
Average +134·5±18·25 lb per acre.	Average +37±18·25 lb per acre.	Average +214·7±21·1 lb per acre.

Root—mean—square—difference between neighbouring control plots =36·5 lb per acre.

Cost of cultivation in man-days per acre for both tests = 69·0.

TABLE No. 7.

GROUNDNUT VARIETY TEST.

Plot.	Crop.	Treatment.	Pounds per acre in shelled nuts.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control Plots.	Treatment Plots.	
D1	Groundnuts	Mache atsugane ...	456		
2	,,	Basse		300	− 138
3	,,	Mache atsugane ...	420		
4	,,	Ceylon		356	− 40
5	,,	Mache atsugane ...	372		
6	,,	Phillipine Pink ...		472	+ 94
7	,,	Mache atsugane ...	384		
8	,,	Damberta		356	− 30
9	,,	Mache atsugane ...	388		
10	,,	Phillipine White ...		296	− 130
11	,,	Mache atsugane ...	464		
12	,,	Basse		372	− 60
13	,,	Mache atsugane ...	400		
14	,,	Ceylon		340	− 84
15	,,	Mache atsugane ...	448		
16	,,	Phillipine Pink ...		316	− 128
17	,,	Mache atsugane ...	440		
18	,,	Damberta		368	− 70
19	,,	Mache atsugane ...	436		
20	,,	Phillipine White ...		276	− 148
21	,,	Mache atsugane ...	412		
22	,,	Basse		304	− 134
23	,,	Mache atsugane ...	464		
24	,,	Ceylon		316	− 156
25	,,	Mache atsugane ...	480		
26	,,	Phillipine Pink ...		228	− 214
27	,,	Mache atsugane ..	404		
28	,,	Damberta		304	− 82
29	,,	Mache atsugane ...	368		
30	,,	Phillipine White ...		204	− 178
31	,,	Mache atsugane ...	396		
		Average ...	427	...	...

Each plot ¼ acre—sown June 5th, 1930—harvested October 30th to November 14th, 1930—Phillipine Pink harvested October 4th–5th, 1930—Plants 12″ apart on 2′ 6″ ridges.

Increase (+) or decrease (−) of plots sown with varieties as compared with plots sown with standard Mache atsugane.

Basse.	Ceylon.	Phillipine Pink.	Damberta	Phillipine White.
− 138	− 40	+ 94	− 30	− 130
− 60	− 84	− 128	− 70	− 148
− 134	− 156	− 214	− 82	− 178

Average −111±25 lb. p.a. −93±25 lb. p.a. −83±25 lb. p.a. −61±25 lb. p.a. −152±25 lb.p.a.

Root—mean—square—difference between neighbouring control plot=42·7.

Cost of cultivation in man-days per acre=69·3.

TABLE No. 8.

CROSS CULTIVATION EXPERIMENT.

Plot.	Crop.	Treatment.	Pounds per acre of threshed grain.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control Plots.	Treatment Plots.	
E22	Guinea-corn	Normal cultivation	389		
23	„ „	Cross cultivation ...		398	+ 19·5
24	„ „	Normal cultivation	364		
25	„ „	Cross cultivation ...		468	+ 132·75
26	„ „	Normal cultivation	306·5		
27	„ „	Cross cultivation ...		317	− 93·75
28	„ „	Normal cultivation	515		
29	„ „	Cross cultivation ...		398	− 106·75
30	„ „	Normal cultivation	494		
31	„ „	Cross cultivation ...		496	− 24
32	„ „	Normal cultivation	546		
		Average ...	436	...	− 14·5

Variety sown—white seeded (black glumes—Farafara (Hausa)—

Each plot ¼ acre—sown May 14th, 1930—harvested November 27th, 1930—Plants 4' apart on 2' 6" ridges.

Increase (+) or decrease (−) of plots cross cultivated as compared with plots cultivated in the normal way.

Average − 14·5 ± 44·9 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 100·5 lb. per acre.

Cost of cultivation in man-days per acre :—

Cross cultivated = 68·9.

Normally cultivated 65·2.

NOTES.

It was only possible to cultivate across the plots for the second hoeing after planting, as at the first hoeing ground was very hard and manure in the ridges had not rotted.

TABLE No. 9.

COTTON STRAIN TEST.

Plot.	Crop.	Treatment.	Pounds per acre of seed cotton.		Increase (+) or decrease (−) from yields of adjacent controls.	
			Control Plots.	Treatment Plots.		
Bomo						
C1	Cotton ...	Strain D	136			
2	,, ...	,, G		182	+23	
3	,, ...	,, D	182			
4	,, ...	,, J		236		+19
5	,, ...	,, D	252			
6	,, ...	,, G		198	−71	
7	,, ...	,, D	286			
8	,, ...	,, J		266		− 3
9	,, ...	,, D	252			
10	,, ...	,, G		132	−94	
11	,, ...	,, D	200			
12	,, ...	,, J		218		−15
13	,, ...	,, D	266			
14	,, ...	,, G		170	−73	
15	,, ...	,, D	220			
16	,, ...	,, J		242		+28
17	,, ...	,, D	208			
18	,, ...	,, G		110	−79	
19	,, ...	,, D	170			
20	,, ...	,, J		184		+ 3
21	,, ...	,, D	192			
22	,, ...	,, G		118	−61	
23	,, ...	,, D	166			
24	,, ...	,, J		160		+ 1
25	,, ...	,, D	152			
26	,, ...	,, G		148	−14	
27	,, ...	,, D	172			
28	,, ...	,, J		170		−20
29	,, ...	,, D	208			
30	,, ...	,, G		140	−57	
31	,, ...	,, D	186			
32	,, ...	,, J		154		−13
33	,, ...	,, D	148			
		Average ...	200	...	−53	0

Variety sown—Allen.

Each plot ¼—sown July 11th, 1930—harvested December 30th, 1930, February 9th, 1931—Plants 12" apart on 2' 6" ridges.

Increase (+) or decrease (−) of plots sown with Strain G as compared with plots sown with Strain D.

Average −53 ± 14 lb. per acre

Increase (+) or decrease (−) of plots sown with Strain J as compared with plots sown with Strain D.

Average 0 ± 14 lb. per acre.

Root—mean—square—difference between neighbouring control plots=39·6 lb. per acre.

Cost of cultivation in man-days per acre=48·4.

TABLE No. 10.

COTTON VARIETY TEST.

Plot.	Crop.	Treatment.	Pounds per acre of seed cotton.		Increase (+) or decrease (−) from yields of adjacent controls.
			Control Plots.	Treatment Plots.	
Bomo					
1	Cotton	Zaria Ordinary...	292		
2	,,	Acala		124	−162
3	,,	Zaria Ordinary...	280		
4	,,	U 4		188	−62
5	,,	Zaria Ordinary...	220		
6	,,	Meso white ...		176	−60
7	,,	Zaria Ordinary...	252		
8	,,	H 21		176	−54
9	,,	Zaria Ordinary...	208		
10	,,	Acala		136	−144
11	,,	Zaria Ordinary...	352		
12	,,	U 4		376	+18
13	,,	Zaria Ordinary...	364		
14	,,	Meso white ...		196	−156
15	,,	Zaria Ordinary...	340		
16	,,	H 21		284	−92
17	,,	Zaria Ordinary...	412		
18	,,	Acala		148	−244
19	,,	Zaria Ordinary...	372		
20	,,	U 4		408	+82
21	,,	Zaria Ordinary...	280		
22	,,	Meso white ...		192	−52
23	,,	Zaria Ordinary...	208		
24	,,	H 21		228	−10
25	,,	Zaria Ordinary...	228		
26	,,	Acala		112	−140
27	,,	Zaria Ordinary...	276		
28	,,	U 4		308	+26
29	,,	Zaria Ordinary...	288		
30	,,	Meso white ...		192	−88
31	,,	Zaria Ordinary...	272		
32	,,	H 21		192	−64
33	,,	Zaria Ordinary...	240		

Variety sown—Allen in control plots.

Each plot $\frac{1}{8}$ acre—sown July 14th, 1930—harvested January 2nd and February 10th, 1931

Plants, 12″ apart on 2′ 6″ ridges.

Increase (+) or decrease (−) of plots sown with Acala as compared with plots sown with Zaria Ordinary.	Increase (+) or decrease (−) of plots sown with U 4 as compared with plots sown with Zaria Ordinary.	Increase (+) or decrease (−) of plots sown with Meso white as compared with plots sown with Zaria Ordinary.
−162	−62	− 60
−144	+18	−156
−244	+82	− 52
−140	+26	− 88
Average −172±28·7 lb. p.a.	Average +16±28·7 lb. p.a.	Average − 89±28·7 lb. per acre.

TABLE No. 10—continued.

Increase (+) or decrease (−) of plots sown with H 21 as compared with plots sown with Zaria Ordinary.
−54
−92
−10
−64
Average −50± 28.7 lb per acre.

Root-mean-square-difference of neighbouring control plots 57·4 lb. per acre.
Cost of cultivation in man-days per acre = 84·8.
Note:—The land on which the experiment was carried out was previously virgin bush and was cleared in May, 1930.

TABLE No. 11.

Cost of Cultivation of Crops for Season, 1930–31, in Man-days and Cattle-days per acre.

(*a*) Cultivation by Cattle.

Crop.	Labour.	Preparation.	Sowing and Establishing.	After cultivation.	Harvesting.	Total.
Millet in Guinea-corn ...	Manual	22	2	13·7	8·5	46·2
	Cattle	9·2	...	...	...	9·2
Guinea-corn	Manual	9·4	3·0	27·1	4·0	43·5
	Cattle	3·4	...	3·0	...	6·4
Cotton	Manual	6·4	6·9	12·6	8·8	34·7
	Cattle	·6	...	2·2	...	2·8
Groundnuts	Manual	2·2	5·5	21·6	33·4	62·7
	Cattle	3·8	...	1·6	1·2	6·6
Mucuna Beans cut for hay...	Manual	4·8	3·5	2·3	11·3	21·9
	Cattle	4·3	...	11·0	...	15·3
Cowpeas	Manual	...	2·2	9·2	1·4	12·8
Interplanted	Cattle	...	...	...	...	...

(*b*) Cultivation by Hand.

Sweet Potatoes	Manual	22·0	11·5	31·2	25·4	90·1

N.B.—The heavy costs for the preparation of the millet crop were due to having changed the ridges from 4 feet to 2 feet 6 inches in the dry season and having ploughed in manure before planting.
The above operations include everything except guarding against monkeys, crows, etc.

TABLE No. 12.

Comparison of Cost of Production and Revenue from Main Crops, 1930–31.

Crop.	Cost in Man-days per acre.	Average yield in lb. per acre.	Cost in Man-days per lb.	Assumed Market value per lb. in pence.	Calculated Return per acre including marketing.	Gross money return per Man-day in pence.	Condition of Produce when sold.
					£ s. d.		
Millet in Guinea-corn	55·4	842	·066	·25	0 14 0½	3·04	Unthreshed.
Guinea-corn ...	49·9	570	·088	·53	1 5 2	6·05	Threshed.
Cotton	37·5	97	·364	·60	0 4 10	·60	Seed cotton.
Groundnuts ...	69·3	427	·162	·54	0 19 2	3.32	Shelled.
Cowpeas (in maize)	12·8	106	·120	·50	0 4 5	4·14	Unshelled.
Sweet Potatoes ...	90·1	6,948	·0013	·11	3 3 8	8·37	Tubers.

Note.—The cost of working cattle is not included in the above charges.

TABLE No. 13.

LACTATIONS COMPLETED DURING THE YEAR.

No. of Cow. 66	Name.	Calving date.	Period of Lactation in Days.	Total Milk Yield in lb.
3	Magajiya ...	20.4.29	465	3,168½
5	Babiye ...	26.3.29	347	1,902¼
6	Bodiye ...	23.7.29	333	2,793½
7	Wujiye ...	30.11.28	428	3,413¾
8	Lemo ...	13.3.30	107	377
9	Barize ...	9.3.29	330	1,865¾
10	Auta ..	12.4.30	60	164¾
11	Dafaliye ...	12.1.30	172	881¼
12	Fodiye ...	17.11.29	77	85¼
14	Mauduye ...	8.12.29	227	1,308¼
15	Rogozo ...	16.2.30	172	1,416¾
18	Danagiye ...	31.3.30	72	131¼
19	Nufu	16.12.29	199	1,263¼
21	Wayu ...	27.1.29	500	1,433
22	Sai	18.11.29	204	1,079½
23	Hodiye ...	10.1.30	133	263
26	Samaru ...	28.12.29	148	245
28	Wodiye ...	26.12.29	61	35¾
30	Rato ...	12.3.30	109	247¼
32	Yelwa ...	30.6.29	398	2,872¾

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Total area of experimental station = 297 acres.

Area under cultivation = 120 acres.

Latitude 8° 30′ North. Longitude 4° 34′ East.

Altitude 920 feet (Approx.)

Mean annual rainfall, 1905-1930—49.53 inches.

Distance from nearest point on coast = 146 miles.

The following officers have been in charge :—

Mr. P. W. T. Boughton-Leigh from 1st April to 9th December, 1930.

Mr. G. W. G. Briggs from 10th December to 31st March, 1931.

Experimental work has been continued on the same lines as in previous years, and has been chiefly concerned with the maintenance of soil fertility by rotational green manuring. This has been regarded as the most important part of our experimental work as it is an attempt to devise a system of permanent cultivation which will be sufficiently attractive to the native farmer, to induce him to adopt it in the place of shifting cultivation which is at present the general practice throughout the Province. Very few farmers in the Ilorin Province own any cattle though most of them keep a few sheep and goats. There is therefore no manure available in any quantity and in order to maintain the yield of his crops the farmer is forced to practice shifting cultivation. The climate is suitable for green manuring and the two main rotations based on green manures which are practised on our farm have given very satisfactory results.

One of these, distinguished as the " old three-year rotation " was commenced in 1924, and is now in its third cycle. It is therefore possible to compare yields of crops grown in 1924, 1927 and 1930. These yields definitely indicate that soil fertility is being maintained and, in some instances, even increased.

The " new three-year rotation ", commenced in 1928, is now only entering its fourth year, and it will be sometime before any indication of its success, or otherwise, will be available.

A test as to the frequency of leguminous crops necessary to maintain soil fertility is also being carried out. In this frequency test, rotations including one and two leguminous crops in a three-year cycle are under observation.

Demonstration plots comparing early maize following a green manure crop, with early maize following a one-year bush fallow have been continued, and are of great interest to parties of visiting farmers.

Other experimental work includes cotton variety yield tests, groundnut variety tests, and time of planting and spacing tests with yams and maize.

The Ilorin sheep purchased in November 1929 have made very satisfactory progress, and the effect of good feeding and careful management is very marked. A ram of the same type was purchased in September 1930, and was turned in with the ewes early in December so that lambing might coincide with the early rains. In February 1931, 26 Hausa sheep were received from Kano; and in March 21 ewes and one ram were transferred from Badeggi.

As a local demand for poultry of the Rhode Island Red type has arisen, a small flock has been commenced with young stock from Moor Plantation, Ibadan.

The yield of fruit from the Citrus orchard has been satisfactory and a number of budded orange and grape fruit trees have been distributed in the district.

The distribution to local farmers of improved groundnut seed grown on the farm has been continued with success, the demand for seed having increased considerably during the last year. Figures for Ilorin (excluding outstations) for last three years are as follows :—

1928	...	...	...	...	**376 lb.**
1929	...	...	...	...	**412 lb.**
1930	...	...	...	...	**1,294 lb.**

The rainfall for 1930 was above the average, 54.31 inches being recorded, as against the average for 26 years of 49.53 inches. The distribution was again slightly abnormal. The short dry season occurring in August was unusually prolonged, only 0.9 inch falling between July 20th and August 31st. The rainfall during September was well above the average for that month, but November was completely dry. The cotton crop suffered as a result of this uneven distribution and was late in maturing.

FERTILITY EXPERIMENTS.

Residual Value of Mucuna. (Table 2).

Test crop of early maize. (Var. Lagos White.)

Average yield of 5 plots following Mucuna = 1,719 lb. dry grain per acre.
Average difference of 4 plots following weed fallow = −765±50 lb. per acre.
Odds that difference is significant = ∞ : 1

The result of this test in previous years has again been confirmed, the yield of maize following mucuna being greatly in excess of the yield of maize following bush fallow. The mucuna on the control plots was sown through the maize in September 1929, the treatment plots being left to revert to weeds after the previous maize crop had been harvested. The difference between the plots was very marked throughout the whole period of growth, and the block was again used for demonstration purposes.

Old Three-year Rotation. (Tables 3 and 4.)

Further results of the old three-year rotation are now available, and amply support similar results published in the 1930 Bulletin.

This rotation commenced in 1924, consists of the following series of crops which, with the exception of mucuna, approximates to local farming practices—

First year—Maize and guinea-corn.

Second year—Yams and cotton.

Third year—Mucuna.

Three blocks of five acres each are continuously cultivated under this rotation, and furnish a very striking example of the benefit derived from the green manure. Two of the blocks were first cropped in 1914, and the third in 1923, and crop yields at the present time compare very favourably with those obtained on native farms.

Some average yields obtained on Blocks A21-40 (first cropped in 1914), and B41-60 (first cropped in 1923) are given below, but fuller particulars will be found in Tables 3 and 4.

Yields given in lb. per Acre.

Block A21-40.

	Yams and Cotton. Lb. per acre.		Maize and Guinea-corn. Lb. per acre.	
1924	5,510	99		
1925	Mucuna			
1926			1,454	601
1927	8,502	93		
1928	Mucuna			
1929			1,497	767
1930	7,375	166		

Block B41-60.

	Yams and Cotton. Lb. per acre.		Maize and Guinea-corn. Lb. per acre.	
1924			1,176	452
1925	11,332	76		
1926	Mucuna			
1927			1,340	632
1928	9,903	194		
1929	Mucuna			
1930			1,287	423

The standard employed in estimating the maintenance of soil fertility is the yield likely to be obtained on a newly cultivated farm. After due allowance has been made for seasonal variation, the above figures are ample evidence that the object of the experiment is being achieved. For instance Block B41-60 was cleared late in 1923 and sown with mucuna. The first crop of economic value therefore was maize and guinea-corn in 1924, and on examining the figures for the same crop in 1930, it will be seen the total combined grain is in excess of the 1924 figures.

Three Series of Three-year Rotations. (Table 5).

Test as to the frequency of leguminous crops necessary to maintain soil fertility.

The three rotations under observation in this test are:—

A	B	C
1. Maize and Beans.	1. Maize and Beans.	1. Groundnuts and Beans.
2. Maize and Beans.	2. Maize and Guinea-corn.	2. Maize and Guinea-corn.
3. Yams.	3. Yams.	3. Yams.

The bean crop in every case has been mucuna.

The test was commenced in 1924 and is being carried out on three blocks of three acres each.

The results which are given in full in Table 5, are inconclusive, and it will be necessary for further cycles of the rotations to be completed before any useful information can be derived from the test.

Early *versus* Late Planting of Yams (Variety Boki). (Table 6.)

Average yield of 5 early planted plots = 8,700 lb. per acre.
Average difference of 4 late planted plots = −4,612±934 lb. per acre.
Odds that difference is significant = ∞ : 1.
Cost of production of early planted yams = £4 9s. 7d. per acre.
Cost of production of late planted yams = £2 14s. 3d. per acre.
Value of early planted yams @ 1s. 2d. per cwt. = £4 11s. 4d.
Value of late planted yams @ 1s. 2d. per cwt. = £2 0s. 10d.

Although it had always been considered that early planting of yams is essential, no experimental trial of this had previously been done on the farm. In this experiment the control plots were planted in November, and the treatment plots in the following April. The result of the trial was definitely conclusive and confirmed the local native practice, and the routine adopted both at Moor Plantation and on this farm in the past. The cost of production of yams planted in April is considerably lower than that of early planted yams, but the cash return per acre in the case of early planted yams more than balances the higher cost of production.

Groundnut Variety Test. (Tables 7 and 8.)

Ilorin *versus* Chinese.

Block C1-20.

Average yield of 10 plots Ilorin variety = 1,319 lb. dry unshelled nuts per acre.
Average difference of 9 plots Chinese variety = +182±58 lb. per acre.
Odds that difference is significant = 1,030 : 1.

Block E29-44.

Average yield of 8 plots Ilorin variety = 1,793 lb. dry unshelled nuts per acre.
Average difference of 7 plots Chinese variety = +1·7±110 lb. per acre.

In this trial, a continuation of trials commenced in 1929, groundnuts were intercropped with guinea-corn grown as a sole crop. The result obtained on Block C1-20 is the first in this series of trials, in which the Chinese variety gave a definitely higher yield than the Ilorin. Generally it is found that the Ilorin variety yields better, but this is offset to a certain extent by the larger size of the Chinese nuts.

The kernel percentage was the same for both varieties, namely 60%. This is usually the case; on one occasion only has the Chinese variety given a higher percentage.

The soil on Block E29-44 is appreciably better than on C1-20.

The results obtained on Block C1-20 are interesting, as it is shown that on land of ordinary fertility an average yield of both groundnuts and guinea-corn can be obtained when the two are intercropped. The economics of this routine require further investi-

gation, but the cost of production of guinea-corn grown through groundnuts is approximately half that of guinea-corn grown as a sole crop. It would appear at first that the cash profit accruing from a combined groundnut and guinea-corn crop would be greater than that from a groundnut crop alone, but the results of two trials in 1929 and 1930 show that this is not the case.

Early Maize (Lagos White) spacing test. (Table 9).

Average yield of 10 control plots = 790 lb. dry grain per acre.
Average difference of 9 treatment plots = +282±65 lb. per acre.
Odds that difference is significant = ∞ : 1.

A spacing test of early maize grown as a sole crop, of one row per ridge two plants per stand, versus two rows per ridge one plant per stand, was carried out on Block G61-79, and the result is very definitely in favour of the latter routine. The soil on this block is distinctly poor. The routine carried out on the treatment plots could only be adopted when maize is grown as a sole crop.

Cotton Variety yield test. (Tables 10 and 11).

Ishan A *versus* Ilorin.

A21-40.

Average yield of 10 plots Ilorin = 166 lb. per acre.
Average difference of 9 plots Ishan A = −10±21 lb. per acre.
Odds that difference is significant = 2 : 1.
Percentage of dirty cotton. Ilorin 25%, Ishan A 15%.

A41-60.

Average yield of 10 plots Ilorin = 124 lb. per acre.
Average difference of 9 plots Ishan A = −7±21 lb. per acre.
Odds that difference is significant = 2 : 1.
Percentage of dirty cotton. Ilorin 16%, Ishan A 8·7%.

This test carried out in previous years, was repeated on Blocks A21-40 and B41-60, and confirms the results previously obtained—namely that Ilorin yields slightly better than Ishan A. The difference is very slight, but is so consistent in the eight tests carried out that one is led to believe that this conclusion is correct. In both cases the cotton was grown through yams. Due to lack of rain early in the growing season the crop suffered considerably from disease but made a good recovery later. On Block A 41-60 it was necessary to clear the cotton from the land by the middle of March in order to prepare for the following groundnut crop. On Block A21-40 however, it was possible to leave the cotton on the land until the end of the month, and a final picking on 26th March resulted in a 20% increase in yield.

TABLE No. 1.

METEOROLOGICAL REPORT FOR 1930.

ILORIN FARM STATION.

Hour of observation, 9 a.m.

Months.	AIR TEMPERATURE.							Relative humidity Sat. 100.	Rainfall in inches 1930.	No. of days.	Average rainfall for 26 years.
	Means.		Range.	ABSOLUTE.							
	Max.	Min.		Max.	Date.	Min.	Date.				
January ...	92	62	30	97	13th	50	2nd	68	...	...	0·20
February ...	97	72	25	100	12th	64	1st	68	·8	1	0·77
March ...	95	74	21	100	27th	68	5th	72	1·49	3	1·99
April ...	92	72	20	95	5th	69	20th	72	2·57	5	4·13
May ...	91	72	19	96	3rd	69	29th	75	7·26	18	6·87
June ...	87	69	18	90	2nd	67	4th	76	12·21	17	7·66
July ...	81	71	10	87	10th	67	29th	82	10·01	16	5·93
August ...	83	69	14	90	27th	68	2nd	75	·9	4	3·83
September ...	86	71	15	90	29th	69	3rd	82	12·28	18	9·91
October ...	88	70	18	92	16th	67	29th	84	4·97	14	6·52
November ...	91	68	23	95	18th	59	22nd	79	·78	2	1·32
December ...	92	69	23	96	27th	60	8th	77	1·04	2	0·40
Totals ...	...	...	...	...	...	...	...	...	54·31	100	49·53
Means ...	89·58	69·81	19·66	94	...	64·75	...	75·83	...	...	...

TABLE No. 2.

EARLY MAIZE. (LAGOS WHITE).

DEMONSTRATION PLOTS SHOWING MAIZE YIELDS AFTER MUCUNA *versus* NO MUCUNA.

Plots E2 1–9.	Treatment.	Yield in lb. dry grain per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
1	Mucuna	1,794	
2	No Mucuna ...	1,131	— 643
3	Mucuna	1,754	
4	No Mucuna ...	889	— 803
5	Mucuna	1,630	
6	No Mucuna ...	923	— 769
7	Mucuna	1,754	
8	No Mucuna ...	862	— 847
9	Mucuna	1,664	

EARLY MAIZE.

Average yield of 5 plots after Mucuna = 1,719 lb. dry grain per acre.

Root—mean—square—difference between adjacent controls = 100 lb. per acre.

Average difference of 4 plots after no Mucuna = −765 ±50

Odds that the difference is significant = ∝ : 1.

Plots ¼ acre, 6′ ridges, stands 1 foot apart, 2 plants per stand.

Seed sown on 15th April, 1930.

Crop harvested 13th August, 1930.

Cost of cultivation in man-days per acre @ 10d. per man-day = 56 (for Mucuna plots).

„ „ „ „ „ „ „ „ „ „ „ „ „ = 51 (for no Mucuna plots).

Percentage dry weight to field weight = 82 (for Mucuna).

„ „ „ „ „ „ = 78·5 (for no Mucuna).

„ of grain on cob = 87·5% (for Mucuna plots).

„ „ „ „ „ = 85% (for no Mucuna plots).

TABLE No. 3.

OLD THREE-YEAR ROTATION.

BLOCK A21–40.

Yields of Yams and Cotton for 1924, 1927 and 1930 in lb. per acre.

Plots A 21–40.	1924.		1927.		1930.	
	Yams.	Cotton.	Yams.	Cotton.	Yams.	Cotton.
21	6,832	40	6,480	93	7,392	51
22	6,944	56	7,360	64	6,944	57
23	8,288	36	7,280	96	7,392	53
24	5,376	48	5,152	63	6,720	44
25	5,040	72	7,284	109	7,280	63
26	2,912	100	5,120	56	8,736	110
27	5,824	116	8,272	151	7,616	169
28	3,360	104	7,940	84	8,400	165
29	5,600	112	10,172	141	8,512	177
30	4,704	88	8,596	74	9,072	130
31	8,064	196	10,196	130	7,952	183
32	3,472	64	8,276	53	7,616	221
33	5,264	160	9,640	140	7,168	177
34	4,032	52	5,612	75	7,616	223
35	6,160	200	9,863	162	6,048	315
36	8,696	48	11,076	61	7,168	223
37	6,160	208	12,872	123	6,720	254
38	6,496	116	10,852	49	6,272	259
39	6,160	92	9,156	91	4,144	216
40	5,824	76	8,836	51	8,736	172
Average	5,510	99	8,502	93	7,375	166

TABLE No. 4.

OLD THREE-YEAR ROTATION.

Block B41–60.

Yields of Maize and Guinea-corn for 1924, 1927 and 1930 in lb. dry grain per acre.

Plots B41–60.	1924.			1927.			1930.		
	Maize.	Guinea-corn.	Combined grain.	Maize.	Guinea-corn.	Combined grain.	Maize.	Guinea-corn.	Combined grain.
41	1,360	571	1,931	2,020	800	2,820	1,699	599	2,298
42	1,299	599	1,898	1,312	760	2,072	1,481	503	1,984
43	1,578	487	2,065	1,936	691	2,627	1,442	507	1,949
44	1,520	658	2,178	1,588	731	2,319	1,357	459	1,816
45	1,364	462	1,826	1,616	660	2,276	1,229	444	1,673
46	1,033	414	1,447	1,088	530	1,618	928	338	1,266
47	1,160	274	1,434	1,240	530	1,770	1,069	369	1,438
48	1,184	479	1,663	1,300	626	1,926	1,224	376	1,600
49	1,526	467	1,993	1,580	702	2,282	1,425	457	1,882
50	1,187	490	1,677	1,516	673	2,189	1,448	413	1,861
51	1,257	520	1,777	1,736	792	2,528	1,547	461	2,008
52	1,209	580	1,789	1,496	726	2,222	1,522	417	1,939
53	1,134	493	1,627	1,188	591	1,779	1,312	436	1,748
54	817	299	1,116	968	470	1,438	1,193	328	1,521
55	1,145	367	1,512	1,136	644	1,780	1,273	426	1,699
56	1,226	451	1,677	1,016	658	1,674	1,392	390	1,782
57	1,294	557	1,851	1,488	766	2,254	1,376	486	1,862
58	953	397	1,350	1,104	549	1,653	1,108	382	1,490
59	680	236	916	932	398	1,330	992	367	1,359
60	598	240	838	544	346	890	721	292	1,013
Average	1,176	452	1,628	1,340	632	1,972	1,287	423	1,710

TABLE No. 5.

THREE SERIES OF THREE-YEAR ROTATIONS.

(TEST AS TO FREQUENCY OF GREEN MANURES NECESSARY TO MAINTAIN SOIL FERTILITY.)

Rotation	*A.*	*B.*	*C.*
1.	Maize and Beans.	Maize and Beans.	Groundnuts and Beans.
2.	Maize and Beans.	Maize and Guinea-corn.	Maize and Guinea-corn.
3.	Yams.	Yams.	Yams.

Plots. R1–6.	Rotation.	1924.		1927.		1930.	
		Maize.	Groundnuts.	Maize.	Groundnuts.	Maize.	Groundnuts.
1	A ...	374		346		668	
2	B ...	384		376		682	
3	C ...		816		1,726		1,762
4	A ...	622		482		978	
5	B ...	618		432		859	
6	C ...		1,116		1,578		1,726

Plots R7–12.	Rotation.	1924.			1927.			1930.		
		Maize.	Guinea-corn.	Total grain.	Maize.	Guinea-corn.	Total grain.	Maize.	Guinea-corn.	Total grain.
7	A	635	...	635	1,134	...	1,134	1,821	...	1,821
8	B	700	437	1,137	786	819	1,605	1,688	481	2,169
9	C	577	585	1,162	950	823	1,773	1,737	531	2,268
10	A	482	...	482	812	...	812	1,534	...	1,534
11	B	560	489	1,049	484	840	1,320	1,291	364	1,655
12	C	372	355	727	536	690	1,220	1,056	451	1,507

Plots R13–18.	Rotation.	1924. *Yams.	1927. Yams.	1930. Yams.
13	A	3,024	5,264	5,376
14	B	7,280	7,280	5,712
15	C	4,928	8,344	4,480
16	A	4,648	8,288	5,488
17	B	11,320	8,512	5,824
18	C	9,128	7,672	4,816

* Yam figures for 1924 cannot be considered reliable as five different varieties were used, all of different yielding capacity.

TABLE No. 6.

EARLY *versus* LATE PLANTING OF YAMS.

Plots A82–100.	Treatment.	Yields in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
82 & 83	Early planted	9,700	
84 & 85	Late planted ...	4,100	−4,450
86 & 87	Early planted	7,400	
88 & 89	Late planted ...	4,200	−4,300
90 & 91	Early planted	9,700	
92 & 93	Late planted ...	4,400	−4,450
94 & 95	Early planted	8,000	
96 & 97	Late planted ...	3,100	−5,250
98 & 99	Early planted	8,700	
100	Early planted	8,700	(Non experimental.)

Yams (Variety Boki).
Average yield 5 control (Early planted) plots = 8,700 lb. per acre.
Root—mean—square—difference adjacent controls = 1,868 lb. per acre.
Average difference 4 treatment (Late planted) plots = $-4{,}612 \pm 934$.
Odds that difference is significant = ∞ : 1.
Plots $\frac{1}{2}$ acre, ridges 6′ apart, stands 2′ 6″ apart.
Control plots planted 1st and 2nd November, 1929.
Treatment plots planted 10th April, 1930.
All plots lifted 6th, 7th and 8th November, 1930.
Cost of cultivation in man-days per acre at 10d. per man-day.

(*a*) Early Yams = 107.
(*b*) Late Yams = 66.

TABLE No. 7.

GROUNDNUT VARIETY TEST.

(*New Three-year Rotation.*)

ILORIN *versus* CHINESE.

Interplanted with Guinea-corn.

Plots C1-20.	Variety.	Dry unshelled nuts per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.	Guinea-corn yields, dry grain per acre in lb.
1	Ilorin	804			352
2	Chinese ...		1,480	+ 504	530
3	Ilorin	1,148			430
4	Chinese ...		1,476	+ 316	536
5	Ilorin	1,172			356
6	Chinese ...		1,344	+ 114	480
7	Ilorin	1,288			390
8	Chinese ...		1,488	+ 216	468
9	Ilorin	1,256			332
10	Chinese ...		1,428	+ 194	302
11	Ilorin	1,212			376
12	Chinese ...		1,472	+ 90	474
13	Ilorin	1,552			364
14	Chinese ...		1,684	+ 134	520
15	Ilorin	1,548			374
16	Chinese ...		1,528	+ 72	476
17	Ilorin	1,652			294
18	Chinese ...		1,756	+ 150	536
19	Ilorin	1,560			388
20	Ilorin	1,784			550
	Non-experimental)				

GROUNDNUTS—Average yield 10 plots Ilorin variety = 1,319 lb. dry unshelled nuts per acre.

Root—mean—square—difference between adjacent controls = 173 lb. per acre.

Average difference 9 plots Chinese variety = + 182 ± 58 lb. per acre.

Odds that difference is significant 1,000 : 1.

Plots ¼ acre, ridges 6 feet apart, stands 1 foot apart in double rows.

Seed rate Ilorin 32 lb. per acre, Chinese 40 lb. per acre. Sown 21st and 22nd March, 1930.

Both varieties lifted 18th, 19th and 20th September, 1930.

Cost of cultivation in man-days per acre at 10d. per man-day = 74.

Percentage decorticated to undecorticated = Ilorin 60%, Chinese 60%.

GUINEA-CORN—Variety Ilorin.

Sown 15th May, 1930 in furrows, stands 2 feet apart, 2 plants per stand, seed rate 12 lb. per acre.

Harvested 22nd December, 1930.

Average yield dry grain per acre = 420 lb.

Percentage dry grain to field weight = 60%.

Cost of cultivation in man-days per acre at 10d. per man-day = 25·6.

TABLE No. 8.

GROUNDNUT VARIETY TEST.

ILORIN *versus* CHINESE.

Plots E29–44.	Variety.	Yields in lb. dry undecorticated nuts per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
29	Ilorin	2,264	
30	Chinese	2,248	+ 66
31	Ilorin	2,100	
32	Chinese	2,068	+ 162
33	Ilorin	1,712	
34	Chinese	1,932	+ 6
35	Ilorin	2,140	
36	Chinese	1,884	− 30
37	Ilorin	1,688	
38	Chinese	1,616	− 6
39	Ilorin	1,556	
40	Chinese	1,552	+ 40
41	Ilorin	1,468	
42	Chinese	1,216	− 226
43	Ilorin	1,416	
44	Chinese	1,744	Non-experimental

GROUNDNUTS—Average yield of 8 plots Ilorin variety = 1,793 lb. dry unshelled nuts per acre.

Root—mean—square—difference between adjacent controls = 291 lb. per acre.

Average difference 7 plots Chinese variety = + 1·7 ± 110 lb. per acre.

Odds that difference is significant = Nil.

Plots $\frac{1}{4}$ acre, ridges 6 feet apart, 2 rows per ridge, stands 1 foot apart, planted 24th March, 1930.

Lifted 18th and 19th August, 1930.

Cost of cultivation in man-days per acre at 10d. per man-day = 95.

Percentage decorticated to undecorticated = Ilorin 60%, Chinese 60%.

TABLE No. 9.

EARLY MAIZE PLANTING TEST.

ONE ROW PER RIDGE, TWO PLANTS PER STAND

versus

TWO ROWS PER RIDGE, ONE PLANT PER STAND.

Plots G61–79.	Treatment.	Yields in lb. dry grain per acre.		Increase (+) or decrease (−) compared with mean of adjacent control.
61	1 Row 2 plants per stand ...	785		
62	2 Rows 1 plant per stand		785	+ 48
63	1 Row 2 plants per stand ...	689		
64	2 Rows 1 plant per stand		1,077	+ 290
65	1 Row 2 plants per stand ...	885		
66	2 Rows 1 plant per stand		1,032	+ 163
67	1 Row 2 plants per stand ...	853		
68	2 Rows 1 plant per stand		1,034	+ 118
69	1 Row 2 plants per stand ...	979		
70	2 Rows 1 plant per stand		1,260	+ 297
71	1 Row 2 plants per stand ...	948		
72	2 Rows 1 plant per stand		1,092	+ 291
73	1 Row 2 plants per stand ...	654		
74	2 Rows 1 plant per stand		1,244	+ 471
75	1 Row 2 plants per stand ...	893		
76	2 Rows 1 plant per stand		1,201	+ 363
77	1 Row 2 plants per stand ...	783		
78	2 Rows 1 plant per stand		1,106	+ 500
79	1 Row 2 plants per stand ...	429		

EARLY MAIZE—(Variety Lagos White.)

Average yield of 10 control plots = 790 lb. dry grain per acre.

Root—mean—square—difference of neighbouring controls = 196.

Average difference 9 treatment plots = $+282 \pm 65$.

Odds that difference is significant = $\propto : 1$.

Plots $\frac{1}{4}$ acre, ridges 6 feet apart. Seed rate control plots 10·5 lb. per acre, treatment plots 19 lb. per acre.

Seed sown 15th April, 1930, harvested 14th August, 1930.

Cost of cultivation in man-days per acre at 10d. per man-day = 47.

TABLE No. 10.

COTTON VARIETY YIELD TEST.

(Old Three-year Rotation)

Ishan A *versus* Ilorin.

(*Planted through Yams*).

Plots A21–40.	Treatment.	Yields in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
21	Ilorin	51	
22	Ishan A	57	+ 5
23	Ilorin	53	
24	Ishan A	44	—14
25	Ilorin	63	
26	Ishan A	110	— 6
27	Ilorin	169	
28	Ishan A	165	— 8
29	Ilorin	177	
30	Ishan A	130	—50
31	Ilorin	183	
32	Ishan A	221	+41
33	Ilorin	177	
34	Ishan A	223	—23
35	Ilorin	315	
36	Ishan A	223	—61
37	Ilorin	254	
38	Ishan A	259	+24
39	Ilorin	216	
40	Ilorin (Non-Experimental)	172	

Average yield 10 plots Ilorin = 166 lb. per acre.

Root—mean—square—difference between adjacent controls = 63 lb. per acre.

Average difference 9 plots Ishan A = −10±21 lb. per acre.

Odds that difference is significant = 2 : 1

Plots ¼ acre, ridges 6 ft. apart, stands 2 ft. 6 inches apart.

Date of planting 2nd July, 1930.

Dates of harvesting 9th, 19th & 28th January, 9th February and 20th March, 1931.

Cost of cultivation in man-days per acre @ 10d. per man-day = 39·2.

TABLE No. 11.

COTTON VARIETY YIELD TEST.

(New Three-year Rotation.)

Ishan A *versus* Ilorin.

(Planted through Yams.)

Plots. A41–60.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
41	Native	201	
42	Ishan A	144	+ 6
43	Native	74	
44	Ishan A	94	+ 11
45	Native	91	
46	Ishan A	79	+ 3
47	Native	60	
48	Ishan A	108	+ 22
49	Native	112	
50	Ishan A	123	0
51	Native	133	
52	Ishan A	120	− 13
53	Native	132	
54	Ishan A	152	− 13
55	Native	197	
56	Ishan A	112	− 38
57	Native	103	
58	Ishan A	77	− 42
59	Native	134	
60	Native ... ... (Non-Experimental)	167	

Average yield 10 plots Ilorin = 124 lb. per acre.

Root—mean—square—difference between adjacent controls = 62 lb. per acre.

Average difference 9 plots Ishan A = -7 ± 21 lb. per acre.

Odds that difference is significant = less than 2 : 1

Plots $\frac{1}{4}$ acre, ridges 6 ft. apart, stands 2 ft. 6 inches apart.

Date of planting 2nd July, 1930.

Dates of harvesting 10th, 20th, 29th January and 10th February, 1931.

Cost of cultivation in man-days per acre at 10d. per man-day = 29·2.

TABLE No. 12.

AVERAGE MONTHLY PRICES OF PRINCIPAL FOOD CROPS IN 1930.

Prices given are those obtaining in Ilorin Market, and are per cwt.

Month.	Yams.		Maize.		Guinea-corn.		Groundnuts.	
	s.	d.	s.	d.	s.	d.	s.	d.
January	1	7	2	7	2	6	4	9½
February	2	4	2	9	2	1¼	2	3½
March	2	6½	2	10½	1	9	5	6
April	3	6	3	2	1	10	5	11
May	3	10½	3	7	2	1½	6	1
June...	4	11	3	4	2	5½	6	3½
July	5	7	3	10	2	8	6	0
August	3	6	3	0½	2	7	5	4
September	2	5	3	0	2	6	5	0
October	1	6	3	1½	2	6	4	6½
November	1	4	3	2½	2	6	4	5
December	1	5	3	0¾	2	4½	4	5¼
Average ...	2	9½	3	2	2	4	5	0½

TABLE No. 13.

Cost of Cultivation of Main Crops, 1930–31.

Average in Man-days per acre.

Crop.	Preparation.	Establishing.	After Cultivation.	Harvesting.	Total.	
Yams	23	12	38	27	100	
Yams...	19	7	34	19	79	114
and Cotton	...	5	17	13	35	
Early Maize ...	16	4	18	11	49	56
and Cover Crop	...	2	5	...	7	
Maize	14	4	16	12	46	69
and Guinea-corn ...	6	3	7	7	23	
Groundnuts... ...	18	9	21	49	97	
Groundnuts... ...	12	8	8	28	56	
Guinea-corn ...	7	3	9	7	26	87
Cover Crop	...	3	2	...	5	
Guinea-corn ...	16	29	18	6	69	
Late Maize... ...	16	5	8	11	40	
Rice	39	33	20	37	129	
Cover Crop	3	4	13	12	32	

TABLE No. 14.

Comparison of Cost of Production and Revenue of Main Crops, 1930–31.

Average Cost of labour 10d. per man-day.

Crops.	Cost of production in man-days per acre.	Average yield in lb. per acre.	Cost of production of crop in man-days per acre.	Market value per lb. at store.	Calculated return per acre.	Gross monetary return per man-day.	Nett monetary return per man-day.	Kind of crop.
Yams	100	7,837	·013	·125d.	980d.	9·8d.	— ·2d.	Tubers.
Early Maize (Grown with Guineacorn)	46	1,284	·036	·3d.	385d.	8·4d.	— 1·6d.	Dry husked cobs.
Late Maize ...	40	1,369	·029	·3d.	411d.	10·3d.	+ ·3d.	Dry husked cobs.
Guineacorn (Grown with Early Maize)	23	742	·033	·188d.	140d.	6·1d.	— 3·9d.	Guinea-corn heads. Unthreshed.
Groundnuts ...	97	1,767	·055	1·0d.	1,767d.	18·2d.	+ 8·2d.	Dry unshelled nuts.
Rice	129	1,310	·099	·93d.	1,218d.	9·5d.	— ·5d.	Dry paddy.
Cotton-Ishan ...	35	112	·312	·5d.	56d.	1·6d.	— 8·4d.	Seed cotton.
Cotton-Ilorin ...	35	128	·273	·5d.	64d.	1·8d.	— 8·2d.	Seed cotton.

KANO PLANTATION—ANNUAL REPORT, 1930.

General.

The following officers were in charge during the season.

Mr. J. W. R. Pedder from 1st January to 11th March.

Mr. E. T. Holmes from 12th March to 11th September.

Mr. J. W. R. Pedder from 12th September to 31st December.

The plantation is situated on light sandy soil, just south of Kano city. The total area is 160 acres of which 146½ acres are under cultivation.

The herd of cattle at the end of the season consisted of 18 oxen, seven cows and seven young stock. The adult stock are all trained for draught purposes. The females are slightly nervous at first but all animals soon settle down and become accustomed to work. During the early part of the planting season, mid May and June, the rainfall was below normal, and the earlier sown crops suffered in consequence, necessitating re-planting in some cases The rains continued into October and this helped to fill the grain of the guinea corn crop. The total fall 33.05″ was slightly below the average for the seven years recorded on the plantation.

General Crop and Cultivation Notes.

A small area was set aside for groundnut and guinea corn progeny rows and a small yield trial with the former crop. Four strains of groundnuts were found to be distinctly promising. The guinea corn progeny rows however were failures due to the seed used not being suited to local climatic conditions. Ploughs and cultivators were used for all the main operations, on the farm, very little additional hand labour now being required. While lifting the groundnut crop it was found that a great saving of labour was effected by ploughing out the haulm and nuts instead of by harvesting by hand in the usual way.

The ploughs and cultivators have not undergone any material change. Certain minor improvements have been made but by keeping the implements more or less standard in design, native artisans become more proficient at constructing and repairing them.

Farmers Tests.—During the season under review three men only were kept on the plantation to practice mixed farming for their own advantage. It is considered that these plantation farmers should now be discontinued and that our efforts should be concentrated on the men in the districts who have taken or wish to take up mixed farming on their own account.

Extension Work.—Three farmers in Bichi District who took up mixed farming last year have had a successful season and are quite satisfied with their results. This also applies to the six farmers in the Taura District who also adopted the system last year. The latter were able to obtain a good profit by selling their working bullocks and buying in untrained animals to replace them. The Emirs of Kano and Kazaure, who in their private capacities, have started mixed farming on their farms are both satisfied with the results of a year's working and intend to extend the area of their farms this year. It is certain that more people will take up mixed farming when the advantages of the scheme, as demonstrated by some of their own number become more apparent to them.

Groundnut Variety Yield Trial.

See Table 1.

	Lb. per acre undecorticated.	Odds that difference is significant.
Average yield of 15 control plots of Dambarta Groundnuts undecorticated	1,631	
Average of 3 plots Basse	+ 68 ± 70	5 : 1
Average difference of 3 plots Philippine Pink	− 417 ± 70	∝ : 1
Average difference of 3 plots Philippine White	+ 265 ± 70	1,111 ∝ : 1
Average difference of 3 plots Ceylon	+ 9 ± 70	
Average difference of a plot Biu	− 475 ± 70	∝ : 1

Over the whole experiment the yield of groundnuts was above the average. Under conditions prevailing last season the variety Philippine White was distinctly superior to any of the other varieties including the control. The increase in yield is such as to warrant further trials. From a sample taken from the bulk of each variety, Plantation Dambarta gave the highest shelling percentage namely 74%, with the other varieties in the following order Philippine Pink 71½%, Ceylon 70½%, Philippine White 67½% and Biu 48%. If these figures are taken into consideration Philippine White still holds a slight advantage in yield above Plantation Dambarta.

Spreading Plantation Dambarta Variety of Groundnuts versus Erect Zaria Variety.

See Table 2.

	Lb. per acre.	Odds that difference is significant.
Average yield of 3 control plots of Plantation Dambarta undecorticated	= 1,987	
Average difference of 2 plots of Zaria Erect Groundnuts undecorticated	= + 53 ± 130	

This experiment was conducted to test:—

(*a*) The two varieties for yield.

(*b*) The ease or otherwise with which the crop could be lifted with the plough.

Considering (*a*) first, although the erect Zaria variety was planted nine inches apart on the ridge as opposed to the spreading variety at one foot six inches there is no significant difference in yield per acre. If the extra cost of planting and cost of seed for the erect variety is taken into consideration it would appear that it is more advantageous to plant the plantation Dambarta variety.

Turning to (*b*) above, it was found that on this soil the spreading variety was more easily ploughed up than the erect. In point of fact a special implement was used for lifting the latter variety after ploughs had been tried without success.

The yield of both varieties was extremely good.

Interplanted Gero Spacing Experiment in Groundnuts.

See Tables 3 and 4.

Gero.	Weight of grain on the head in lb. per acre.	Odds that difference is significant.
Average yield of Gero from 16 control plots, *i.e.*, 3 rows of Gero interplanted in Groundnuts ...	756	
Average difference of 5 plots Gero 2 rows interplanted in Groundnuts...	+ 105·6 ± 75·3	11 : 1
Average difference of 4 plots Gero 4 rows interplanted in Groundnuts...	− 65·2 ± 84	3 : 1

Groundnuts.	Weight of nuts undecorticated lb. per acre.	Odds that difference is significant.
Average yield of Groundnuts from 15 control plots, *i.e.*, Gero 3 interplanted	567	
Average difference of 5 plots of Groundnuts alone	+ 559 ± 40	: 1
Average difference of 5 plots of Groundnuts with Gero 2 interplanted	+ 52 ± 40	10 : 1
Average difference of 4 plots of Groundnuts with Gero 4 interplanted	− 52 ± 45	7 : 1

Crop.	Average yield per acre Groundnuts decorticated.	Gero as grain.	Groundnuts 0·70d. per lb.	Value Gero 0·86d. per lb.	Gross return per acre.
			£ s. d.	£ s. d.	£ s. d.
Groundnuts and 3 rows Gero	419·6	409·6	1 4 5½	1 10 1	2 14 6½
Groundnuts alone ...	833	—	2 8 7	—	2 8 7
Groundnuts and 2 rows Gero	458·1	361·3	1 6 9	1 5 11	2 12 8
Groundnuts and 4 rows Gero	381·1	383·5	1 2 3	1 7 6	2 9 9

The result of this experiment confirms that of a somewhat similar experiment conducted last season, the difference being that the gero (bulrush millet) was then interplanted seven, five, and three rows per plot in the groundnut crop. It was then found that material advantage was gained by interplanting three rows of gero, and that the number of rows of gero per plot did not greatly affect the total yield of the gero

Which practice is most profitable depends on the current price of groundnuts. At present prices it would appear more profitable to interplant three rows of gero in the groundnut crop.

Permanent Demonstration Plot Cotton.

See Table 5.

	Lb. seed cotton per acre.	Odds that difference is significant.
Average yield of 13 control plots seed cotton ... ... =	128	
Average difference of 12 plots manured at 3 tons per acre ... ... =	+ 46 ± 11	50,000 : 1

It is intended to grow a crop of cotton on this area every year and to apply farm yard manure to the treatment plots at the rate of three tons per acre. The control plots which have never been manured since the plantation was taken over, will continue unmanured.

The soil in this area is somewhat shallow and is inclined to be easily affected by drought, and in consequence the crop grown is usually somewhat below average.

Cotton Variety Test Kano Strain versus Strain D and Strain J. *See* Table 6.

	Lb. per acre.	Odds that difference is significant.
Average yield of seed cotton from 17 control plots	436	—
Average difference of 8 plots of Strain D	− 170 ± 27	∞ : 1
Average difference of 8 plots of Strain J	− 105·5 ± 27	20,000 : 1

This experiment was designed to test the cotton strains D and J which had been selected by the Botanist for trial on this plantation against the control Kano strain. This latter strain has been grown annually on the plantation for seven years and is now acclimatised and has proved a good yielder during recent years. The original seed was an Allen strain which came from Maigana and it is now known as K1.

The results show conclusively that the amount of seed cotton produced per acre by Kano strain is considerably higher than that produced by either strain D or J. Also throughout the whole growing period the Kano strain was considerably more forward and was not so extensively attacked by either disease or insects.

Ordinary Cultivation versus Dry Season Cultivation.

See Tables 7 and 8.

Block A.

	Lb. per acre.	Odds that difference is significant.
Average yield of guinea-corn on the head from 9 control plots	= 1,676	—
Average difference in yields from 4 plots continuous dry season cultivation ...	= + 50 ± 120	—
Average difference in yields from 4 plots one dry season cultivation	= − 3 ± 120	—

Block B.

Average yield guinea-corn on the head from 8 control plots	= 1,116	—
Average difference in yields from 4 plots continuous dry season cultivation ...	= + 21 ± 144	—
Average difference in yield from 3 plots one dry season cultivation	= − 30 ± 166	—

The treatments were continuous dry season cultivation versus one dry season cultivation. In the first case the land during the dry season (December to mid May) was cultivated once a week and in the second case it only received one cultivation. From planting to harvest all plots, including controls, received the same treatment.

It will be seen that there is no significant difference in the yields of guinea corn when the land was either cultivated or left uncultivated during the dry season. Those plots which had received cultivation were generally cleaner during the growing period and more easily worked.

The yields of guinea corn are good especially from Block A.

Guinea-corn Spacing Experiment

See Table 9.

	Lb. per acre grain on head.	Odds that difference is significant.
Average yield of 9 control plots stands at 3′ 3″	1,064·4	—
Average difference of 4 plots stands 2′ 6″ apart	− 22 ± 113·5	—
Average difference of 4 plots stands 4′ 0″ apart	− 159 ± 113·5	12 : 1

From these results it would appear that guinea corn gives the optimum yield when planted three feet three inches apart on the ridges. The ridges were two feet five inches apart.

The results however are not conclusive, and the crop itself was not level even taking into consideration the different spacings tested.

For practical purposes three feet three inches spacing is perhaps the most economical and easily worked, especially bearing in mind the usual method of interplanting cowpeas in the crop.

Time of Singling and Hoeing Guinea-corn.

See Table 10.

	Lb. per acre.	Odds that difference is significant.
Average yield of guinea-corn on the head from 9 control plots singled and hoed 14 days after planting	918	—
Average difference of 4 plots hoed and singled 21 days after planting... ...	+ 20 ± 69	—
Average difference of 4 plots hoed and singled 28 days after planting... ...	− 125 ± 69	27 : 1

The result of this experiment definitely shows that the best time to single and hoe the guinea corn crop is from 14 to 21 days after planting and that if these operations are left beyond this time the ultimate yield of the crop is adversely affected.

Time of Application of Farm-yard Manure Guinea-corn.

See Table 11.

	Lb. per acre.	Odds that difference is significant.
Average yield guinea-corn on the head of 9 control plots with 3 tons Farm-yard Manure applied dry in April ...	1,197	—
Average difference 4 plots with 3 tons Farm-yard Manure per acre applied May	− 35 ± 70	—
Average difference 4 plots with 3 tons Farm-yard Manure per acre applied to growing crop	+ 6·25 ± 70	—

It was found last season that when manure was applied to the land in a damp condition just before planting, the crop suffered severe damage from the attacks of the larvæ of a dung beetle, which destroyed the young seedlings. The native farmer usually prefers to top dress the growing plant by placing a small quantity of manure around the base of each plant. It is likely that his method is dictated more by a desire to make the fullest use of the small quantity of manure available to him, than by fear of attack of insect pests. It was however considered desirable to gain some information as to the best method of applying manure, and F.Y.M. was applied to all plots at the rate of three tons per acre. That applied in April was allowed to dry out and was then turned in, the May dressing was turned in at once, and the remaining treatment consisted of a top dressing to the growing crop. Neither method caused any great difference to the yield of the crop, and the effect of the different treatments on the incidence of beetle larvæ could not be ascertained as none of these made their appearance on any of the plots.

Comparison of Cost of Production and Revenue from Main Crops 1930 Season *See* Tables 12 and 13.

During the season under review the production of grain crops appears to have paid the farmer better for the labour expended than any of the other crops. This is the usual state of affairs in the Kano area, where the population is high and consequently food crops are of paramount importance.

TABLE No. 1.

Groundnuts Yield Trial.

Plot.	Treatment.	Weight undecorticated lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
B18-33				
18 (1)	Plantation Dambarta	1,852		
18 (2)	Basse		1,894	+ 100
19 (1)	Dambarta	1,736		
19 (2)	Philipine Pink		1,274	− 442
20 (1)	Plantation Dambarta	1,696		
20 (2)	Philipine White		1,896	+ 152
21 (1)	Plantation Dambarta	1,792		
21 (2)	Ceylon		1,726	− 50
22 (1)	Plantation Dambarta	1,760		
22 (2)	Biu		1,192	− 474
23 (1)	Plantation Dambarta	1,572		
23 (2)	Basse		1,722	+ 141
24 (1)	Plantation Dambarta	1,590		
24 (2)	Philipine Pink		1,188	− 426
25 (1)	Plantation Dambarta	1,638		
25 (2)	Philipine White		2,088	+ 469
26 (1)	Plantation Dambarta	1,600		
26 (2)	Ceylon		1,740	+ 20
27 (1)	Plantation Dambarta	1,840		
27 (2)	„ „	1,610		Non-experimental.
28 (1)	„ „	1,376		
28 (2)	Basse		1,304	− 38
29 (1)	Plantation Dambarta	1,308		
29 (2)	Philipine Pink		1,048	− 384
30 (1)	Plantation Dambarta	1,556		
30 (2)	Philipine White		1,740	+ 175
31 (1)	Plantation Dambarta	1,574		
31 (2)	Ceylon		1,632	+ 57
32 (1)	Plantation Dambarta	1,576		
32 (2)	„ „	1,362		
33 (1)	„ „	1,560		Non-experimental.
33 (2)	„ „	1,550		

Each plot ⅛ acre. Sown 16th June, 1930. Lifted 21st October, 1930.

Increase (+) or decrease (−) of 3 plots Ceylon compared with Dambarta.

− 50 lb per acre.
+ 20 „ „ „
+ 57 „ „ „

Average = + 9±70 lb per acre.

Increase (+) or decrease (−) of a plot Biu compared with Dambarta.

− 475

Average = − 475±121 lb per acre.

Increase (+) or decrease (-) of 3 plots Basse compared with Dambarta.

+ 100 lb per acre.
+ 141 „ „ „
− 38 „ „ „

Average = + 68 ± 70 lb per acre.

Increase (+) or decrease (−) of 3 plots Philipine Pink compared with Dambarta.

− 442 lb per acre.
− 426 „ „ „
− 384 „ „ „

Average = − 417±70 lb per acre.

TABLE No. 1—continued.

Increase (+) or decrease (−) of 3 plots Philipine White compared with Dambarta.

+ 152 lb per acre.
+ 469 „ „ „
+ 175 „ „ „

Average = + 265±70 lb per acre.

Root—mean—square—of neighbouring controls = 121 lb per acre.

Percentage Kernels to total Groundnuts.

Dambarta ...	74%
Basse	68%
Philipine Pink	71½%
Philipine White	67½%
Ceylon	70½%
Biu	48%

TABLE No. 2.

Groundnuts Spreading *versus* Erect Varieties.

Plot.	Treatment.	Weight in lb. per acre undecorticated.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B.				
1	Spreading Plantation Dambarta	2,051		
2	Erect Zaria		1,592	− 5
3	Spreading Kano	1,864		
4	Erect Zaria		2,066	+112
5	Spreading Kano	2,045		
6	„ „	2,096		
7	„ „	1,892		

Each plot $\frac{17}{28}$ acre. Sown 14th June, 1930. Lifted 23rd October, 1930.

Spreading Kano planted 1′ 6″ apart.
Erect Zaria 9″ apart on the ridge.

Increase (+) or decrease (−) of 2 plots Zaria Erect Groundnuts as compared with Plantation Dambarta.

− 5 lb per acre.
+112 „ „ „

Average = + 53±130 lb per acre.

Root—mean—square—difference between pairs of neighbouring control = 184 lb per acre.

Cost in man-days per acre = 90·2

Percentage Kernels to total Groundnuts Spreading Variety = 74%.
Erect Variety = 74%.

TABLE No. 3.

GERO VARIOUS ROWS INTERPLANTED IN GROUNDNUTS YIELD GERO.

Block plot.	Treatment Variety.	Weight on the head in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls
N 30–59.				
30	Gero 3 rows per plot	369		
31	No Gero	—		
32	Gero 3 rows per plot	622		
33	„ 2 „ „ „		650	− 59
34	„ 3 „ „ „	796		
35	„ 4 „ „ „		704	− 86
36	„ 3 „ „ „	785		
37	No Gero	—		
38	Gero 3 rows per plot	772		
39	„ 2 „ „ „		708	− 226
40	„ 3 „ „ „	1,092		
41	„ 4 „ „ „		904	+ 20
42	„ 3 „ „ „	677		
43	No Gero	—		
44	Gero 3 rows per plot	736		
45	„ 2 „ „ „		652	− 84
46	„ 3 „ „ „	736		
47	„ 4 „ „ „		718	− 75
48	„ 3 „ „ „	850		
49	No Gero	—		
50	Gero 3 rows per plot	872		
51	„ 2 „ „ „		772	− 88
52	„ 3 „ „ „	848		
53	„ 4 „ „ „		696	− 120
54	„ 3 „ „ „	784		
55	No Gero	—		
56	Gero 3 rows per plot	772		
57	„ 2 „ „ „		660	− 71
58	„ 3 „ „ „	690		
59	„ 3 „ „ „	710		

Each plot ¼ acre. Sown 15th May, 1930. Harvested 1st September, 1930.
Percentage grain to grain on the head = 55½%.

Increase (+) or decrease (−) of 5 plots with 2 rows Gero interplanted compared with 3 rows.

− 59 lb. per acre.
−226 „ „ „
− 84 „ „ „
− 88 „ „ „
− 71 „ „ „

Average = −105·6±75·3 lb. per acre.

Increase (+) or decrease (−) of 4 plots with 4 rows Gero interplanted compared with 3 rows.

− 86 lb. per acre.
+ 20 „ „ „
− 75 „ „ „
−120 „ „ „

Average = − 65·2±84 lb. per acre.

Root—mean—square—of neighbouring controls = 168 lb. per acre.
Cost in man-days per acre = 96·5.

TABLE No. 4.

GERO VARIOUS ROWS INTERPLANTED IN GROUNDNUTS—YIELD GROUNDNUTS (UNDECORTICATED).

Plot.	Treatment.	Weight in lb. per acre undecorticated.	Increase (+) or decrease (−) compared with mean of adjacent controls.
N30–59.			
30	Groundnuts and Gero 3	310	
31	„ „	748	+ 399
32	„ „ 3	388	
33	„ „ 2	356	+ 107
34	„ „ 3	510	
35	„ „ 4	555	− 7
36	„ „ 3	614	
37	„	1,128	+ 600
38	„ „ 3	550	
39	„ „ 2	590	+ 78
40	„ „ 3	474	
41	„ „ 4	411	− 57
42	„ „ 3	462	
43	„	1,135	+ 572
44	„ „ 3	664	
45	„ „ 2	738	+ 43
46	„ „ 3	726	
47	„ „ 4	582	− 90
48	„ „ 3	618	
49	„	1,384	+ 751
50	„ „ 3	648	
51	„ „ 2	764	+ 152
52	„ „ 3	576	
53	„ „ 4	531	− 56
54	„ „ 3	598	
55	„	1,096	+ 473
56	„ „ 3	648	
57	„ „ 2	568	− 118
58	„ „ 3	724	
59	„ „ 3	632	

Each plot ¼ acre. Sown 15th June, 1930. Harvested 30th November, 1930.

Percentage decorticated Kernels to undecorticated Groundnuts = 74%.

TABLE No. 4—continued.

Increase (+) or decrease (−) of 5 plots Groundnuts alone compared with Groundnuts and 3 rows Gero.	Increase (+) or decrease (−) of 5 plots Groundnuts and Gero 2 compared with Groundnuts and Gero 3.
+399 lb. per acre.	+ 107 lb. per acre.
+600 „ „ „	+ 78 „ „ „
+572 „ „ „	+ 43 „ „ „
+751 „ „ „	+ 152 „ „ „
+473 „ „ „	− 118 „ „ „
Average = +559±40 lb. per acre.	Average = +52±40 lb. per acre.

Increase (+) or decrease (−) of 4 plots Groundnuts and Gero 4 compared with Groundnuts and Gero 3.

− 7 lb. per acre.
−57 „ „ „
−90 „ „ „
−56 „ „ „

Average = −52±45 lb. per acre

Root—mean—square—of neighbouring controls = 90

Cost in man-days per acre = 96·5.

TABLE No. 5.

Permanent Demonstration Plot Cotton.

Block Plot.	Variety Treatment.	Weight on the lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
E1–25.			
1	Standard No F. Y. M.	100	
2	3 tons per acre F. Y. M.	122	+ 11
3	No F. Y. M.	122	
4	3 tons per acre F. Y. M.	215	+ 192
5	No F. Y. M.	125	
6	3 tons per acre F. Y. M.	190	+ 57
7	No F. Y. M.	142	
8	3 tons F. Y. M.	182	+ 39
9	No F. Y. M.	145	
10	3 tons per acre F. Y. M.	165	+ 53
11	No F. Y. M.	80	
12	3 tons per acre F. Y. M.	97	+ 19
13	No F. Y. M.	77	
14	3 tons per acre F. Y. M.	125	+ 8
15	No F. Y. M.	157	
16	3 tons per acre F. Y. M.	215	+ 44
17	No F. Y. M.	185	
18	3 tons per acre F. Y. M.	192	+ 35
19	No F. Y. M.	130	
20	3 tons per acre F. Y. M.	157	+ 34
21	No F. Y. M.	117	
22	3 tons per acre F. Y. M.	160	+ 23
23	No F. Y. M.	157	
24	3 tons per acre F. Y. M.	182	+ 41
25	No F. Y. M.	125	

Each plot 1/10 acre. Sown 20th June, 1930. Harvested December, 1930.

Increase (+) or decrease (−) of twelve plots manured at the rate of 3 tons per acre F. Y. M. compared with no manure.

+ 11
+ 192
+ 57
+ 39
+ 53
+ 19
+ 8
+ 44
+ 35
+ 34
+ 23
+ 41

Average = + 46±11 lb. per acre.

Root-mean-square—of neighbouring controls = 38·7 lb. per acre.

Cost in man-days per acre = 40·

TABLE No. 6.

COTTON VARIETY TEST. KANO STRAIN *versus* STRAIN D AND STRAIN J.

Plot.	Treatment.	Weight in lb. per acre seed cotton.	Increase (+) or decrease (−) compared with mean of adjacent control.
Block M.			
1 (1)	Kano	348	
1 (2)	Strain D	226	− 176
2 (1)	Kano	456	
2 (2)	Strain J	312	− 142
3 (1)	Kano	452	
3 (2)	Strain D	294	− 199
4 (1)	Kano	534	
4 (2)	Strain J	340	− 165
5 (1)	Kano	476	
5 (2)	Strain D	264	− 217
6 (1)	Kano	486	
6 (2)	Strain J	420	− 79
7 (1)	Kano	512	
7 (2)	Strain D	340	− 181
8 (1)	Kano	530	
8 (2)	Strain J	394	− 169
9 (1)	Kano	596	
9 (2)	Strain D	338	− 196
10 (1)	Kano	472	
10 (2)	Strain J	418	− 94
11 (1)	Kano	552	
11 (2)	Strain D	264	− 226
12 (1)	Kano	428	
12 (2)	Strain J	378	− 76
13 (1)	Kano	480	
13 (2)	Strain D	356	− 56
14 (1)	Kano	344	
14 (2)	Strain J	220	− 79
15 (1)	Kano	254	
15 (2)	Strain D	152	− 109
16 (1)	Kano	268	
16 (2)	Strain J	210	− 40
17 (1)	Kano	232	

Each plot $\frac{1}{8}$ acre. Sown 18th June, 1930. Harvested November, 1930 to January, 1931.

Increase (+) or decrease (−) of 8 plots Strain D compared with Kano Strain.

− 176 lb. per acre.
− 199 " " "
− 217 " " "
− 181 " " "
− 196 " " "
− 226 " " "
− 56 " " "
− 109 " " "

Average = − 170 ± 27 lb. per acre.

Increase (+) or decrease (−) of 8 plots Strain J compared with Kano Strain.

− 142 lb. per acre.
− 165 " " "
− 79 " " "
− 169 " " "
− 94 " " "
− 76 " " "
− 79 " " "
− 40 " " "

Average = − 105 ± 27 lb. per acre.

Root—mean—square—of neighbouring controls = 77 lb. per acre.
Cost in man-days per acre = 57·6.

TABLE No. 7.

Ordinary Cultivation *versus* Dry Season Cultivation

Yield Guinea-corn.

Plot.	Treatment.	Weight on the head in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block A.			
51	Ordinary Cultivation	1,535	
52	Dry Season Cultivation once ...	1,828	+ 109
53	Ordinary Cultivation	1,904	
54	Dry Season Cultivation Continuous	1,993	+ 69
55	Ordinary Cultivation	1,944	
56	Dry Season Cultivation once ...	1,727	− 88
57	Ordinary Cultivation	1,687	
58	Dry Season Cultivation Continuous	1,552	− 138
59	Ordinary Cultivation	1,694	
60	Dry Season Cultivation once ...	1,800	+ 67
61	Ordinary Cultivation	1,772	
62	Dry Season Cultivation Continuous	1,860	+ 34
63	Ordinary Cultivation	1,880	
64	Dry Season Cultivation once ...	1,579	− 99
65	Ordinary Cultivation	1,476	
66	Dry Season Cultivation Continuous	1,572	+ 236
67	Ordinary Cultivation	1,197	

Each plot ¼ acre. Sown 16th May, 1930. Harvested 13th November, 1930.

Percentage grain to grain on the head = 70¾%.

Increase (+) or decrease (−) of 4 plots of continuous dry season cultivation as compared with ordinary cultivation.	Increase (+) or decrease (−) of 4 plots with one dry season cultivation as compared with ordinary cultivation.
+ 69 lb. per acre.	+ 109 lb. per acre.
− 138 „ „	− 88 „ „
+ 34 „ „	+ 67 „ „
+ 236 „ „	− 99 „ „
Average = + 50 ± 120 lb. per acre.	Average = − 3 ± 120 lb. per acre.

Root—mean—square—difference of neighbouring controls = 241.

Cost in man-days per acre = 55·4.

TABLE No. 8.

Ordinary Cultivation *versus* Dry Season Cultivation Yield Guinea-corn.

Plot.	Treatment.	Weight on the head in lb. per acre.	Increase (+) or decrease (-) compared with mean of adjacent controls.
Block B.			
53	Ordinary Cultivation	744	
54	Dry Season Cultivation Continuous	1,192	+ 195
55	Ordinary Cultivation	1,250	
56	Dry Season Cultivation once ...	1,260	— 1
57	Ordinary Cultivation	1,272	
58	Dry Season Cultivation Continuous	1,296	— 29
59	Ordinary Cultivation	1,378	
60	Dry Season Cultivation once ...	1,248	— 110
61	Ordinary Cultivation	1,339	
62	Dry Season Cultivation Continuous	1,264	— 47
63	Ordinary Cultivation	1,248	
64	Dry Season Cultivation once ...	1,201	+ 20
65	Ordinary Cultivation	1,115	
66	Dry Season Cultivation Continuous	815	— 34
67	Ordinary Cultivation	583	

Each plot ¼ acre. Sown 16th May, 1930. Harvested 13th November, 1930.

Percentage grain to grain on the head = 70¼%.

Increase (+) or decrease (−) of 4 plots of continuous dry season cultivation as compared with ordinary cultivation.	Increase (+) or decrease (−) of 3 plots of one dry season cultivation as compared with ordinary cultivation.
+ 195 lb. per acre.	− 1 lb. per acre.
− 29 „ „	− 110 „ „
− 47 „ „	+ 20 „ „
− 34 „ „	
Average = + 21 ± 144 lb. per acre.	Average = − 30 ± 166 lb. per acre.

Root—mean—square—difference of neighbouring controls = 288 lb. per acre.

Cost in man-days per acre = 55·4.

TABLE No. 9.

GUINEA-CORN SPACING EXPERIMENT.

Plot.	Variety Treatment.	Weight on the head in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
H. Block.			
43	3′ 3″ *i.e.* 10 rows per plot	1,687	
44	2′ 6″ „ 13 „ „	1,395	− 248
45	3′ 3″ „ 10 „ „	1,599	
46	4′ 0″ „ 8 „ „	1,098	− 219
47	3′ 3″ „ 10 „ „	1,036	
48	2′ 6″ „ 13 „ „	935	− 79
49	3′ 3″ „ 10 „ „	992	
50	4′ 0″ „ 8 „ „	797	− 222
51	3′ 3″ „ 10 „ „	1,046	
52	2′ 6″ „ 13 „ „	1,124	+ 117
53	3′ 3″ „ 10 „ „	969	
54	4′ 0″ „ 8 „ „	782	− 167
55	3′ 3″ „ 10 „ „	929	
56	2′ 6″ „ 13 „ „	914	+ 120
57	3′ 3″ „ 10 „ „	660	
58	4′ 0″ „ 8 „ „	633	− 28
59	3′ 3″ „ 10 „ „	662	

Each plot ¼ acre. Sown 18th July, 1930. Harvested 5th November, 1930.

Hand Cultivation.

Percentage grain to grain on the head = 70¼%.

Increase (+) or decrease (−) of 4 plots planted 2′ 6″ compared with those planted 3′ 3″.	Increase (+) or decrease (−) of 4 plots planted 4′ 0″ compared with those planted 3′ 3″.
− 248 lb. per acre.	− 219 lb. per acre.
− 79 „ „	− 222 „ „
+ 117 „ „	− 167 „ „
+ 120 „ „	− 28 „ „
Average = − 22 ± 113·5 lb. per acre.	Average = − 159 ± 113·5 lb. per acre.

Root—mean—square—difference between neighbouring controls = 227 lb. per acre.

Cost in man-days per acre = 41·2.

TABLE No. 10.

Time of Singling and First Hoeing Experiment, Guinea-corn.

Plot.	Treatment.	Weight on the head lb per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
K. 43–59			
43	Singled and hoed 14 days after planting	1,024	
44	„ „ 21 „ „ ...	939	− 15
45	„ „ 14 „ „ ...	884	
46	„ „ 28 „ „ ...	707	− 212
47	„ „ 14 „ „ ...	954	
48	„ „ 21 „ „ ...	903	+ 27
49	„ „ 14 „ „ ...	799	
50	„ „ 28 „ „ ...	854	− 80
51	„ „ 14 „ „ ...	1,070	
52	„ „ 21 „ „ ...	1,071	+ 65
53	„ „ 14 „ „ ...	943	
54	„ „ 28 „ „ ...	724	− 189
55	„ „ 14 „ „ ...	884	
56	„ „ 21 „ „ ...	901	+ 3
57	„ „ 14 „ „ ...	913	
58	„ „ 28 „ „ ...	833	− 21
59	„ „ 14 „ „ ...	795	

Each plot ¼ acre. Sown 17th May, 1930. Harvested 18th November, 1930.

Percentage grain to grain on the head = 70¾%.

Increase (+) or decrease (−) of 4 plots hoed and singled 21 days after planting compared with normal time, *i.e.* 14 days.

− 15 lb. per acre.
+ 27 „ „ „
+ 65 „ „ „
+ 3 „ „ „

Average = + 20 ± 69 lb per acre.

Increase (+) or decrease (−) of 4 plots hoed and singled 28 days after planting compared with normal time, *i.e.* 14 days.

−212 lb. per acre.
− 80 „ „ „
−189 „ „ „
− 21 „ „ „

Average = −125 ± 69 lb per acre.

Root—mean—square—difference between pairs of neighbouring controls = 138.

Cost in man-days per acre = 31·6.

TABLE No. 11.

Time of Application of F.M.Y. Experiment, Yields Guinea-corn.

Plot.	Variety Treatment.	Weight on the head in lb. per acre.		Increase (+) or decrease (−) compared with adjacent controls.
Block K.				
1	F.Y.M. applied April prior rains	1,268		
2	„ „ May damp ...		1,198	+ 12
3	„ „ April	1,108		
4	„ „ to growing crop		1,274	+ 102
5	„ „ April	1,240		
6	„ „ May		1,082	− 138
7	„ „ April	1,200		
8	„ „ to growing crop		1,136	− 33
9	„ „ April	1,138		
10	„ „ May		1,160	+ 1
11	„ „ April	1,180		
12	„ „ to growing crop		1,180	− 104
13	„ „ April	1,388		
14	„ „ May		1,254	− 15
15	„ „ April	1,150		
16	„ „ to growing crop		1,188	+ 60
17	„ „ April	1,106		

Each plot $\frac{1}{4}$ acre. Sown 18th May, 1930. Harvested 7th November, 1930.

F.Y.M. applied at the rate of 3 tons per acre.

Percentage grain to grain on the head = $70\frac{3}{4}\%$.

Increase (+) or decrease (−) of 4 plots with F.Y.M. applied damp at the rains in May compared with F.Y.M. applied in April.

+ 12 lb. per acre.
−138 „ „ „
+ 1 „ „ „
− 15 „ „ „

Average = − 35 ± 70 lb. per acre.

Increase (+) or decrease (−) of 4 plots with F.Y.M. applied, after the crop is up, compared with F.Y.M. applied in April.

+102 lb. per acre.
− 33 „ „ „
−104 „ „ „
+ 60 „ „ „

Average = + 61 ± 70 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 140 lb. per acre.

Cost in man-days per acre = 40·5.

TABLE No. 12.

COST OF MAIN CROPS IN MAN-DAYS PER ACRE.

Crop.	Preparation.	Planting.	Cultivation.	Harvest.	Store Work.	Total.
Guinea-corn	5·3	5·3	15·1	8·4	1·1	35·2
Groundnuts	6·4	7·7	14·8	50·4	9·0	88·3
Cotton	5·1	6·2	19·0	18·4	1·6	50·3
Gero	3·7	1·4	7·4	12·8	0·5	25·8
Legumes single crop	3·1	6·4	18·2	10·7	1·5	39·9
Legumes Interplanted	—	0·6	0·6	2·2	—	3·4

TABLE No. 13.

COMPARISON OF COST OF PRODUCTION AND REVENUE FROM MAIN CROPS 1930 SEASON.

Crop.	Cost in man-days per acre.	Average yield in lb. per acre.	Cost of crop in man-days per lb.	Assumed market value per lb.	*Calculated return per acre at nearest market.	Gross monetary return per day.	Nature of crop as sold.
					£ s. d.		
Guinea-corn	35·2	855·4	0·041	0·77d.	2 11 11	17·7d.	Grain.
Cotton	50·3	368	0·136	1·0d.	1 10 3	7·2d.	Seed cotton.
Groundnuts	88·3	1161·1	0·076	0·70d.	3 4 10	8·8d.	Decorticated.
Gero	25·8	419·6	0·062	0·86d.	1 9 0	13·5d.	Grain.

*Transport to market at Guinea-corn ... ... ·02d. per lb.
Deducted from return Cotton ... ... ·014d. „ „
Groundnuts ... ... ·03d. „ „
Gero ... ... ·03d. „ „

TABLE No. 14.

MONTHLY RAINFALL, 1930.

Month.	Rainfall in inches, Plantation.	Average for 7 years at Plantation.
January	—	—
February	—	—
March	—	0·16
April	—	0·27
May	2·38	2·49
June	2·78	4·82
July	10·70	8·92
August	11·38	11·77
September	4·73	5·12
October	1·08	0·70
November	—	—
December	—	—
Total	33·05	34·25

KWORRE IRRIGATION FARM, SOKOTO:

BULLETIN REPORT, 1930.

The following Superintendents of Agriculture worked on the station during 1930:—

Mr. B. G. Owen 1st January to 15th June.

Mr. J. H. Palmer 1st January to 24th March and 22nd September to 31st December.

Mr. R. Turner 30th March to 31st December.

This report is divided as follows:—

(A) Dry Season Cropping 1929-30,
(B) Wet Season Cropping 1930,
(C) Other Information.

(A) *Dry Season 1929-30.*—During this period one or two rather useful results were obtained. It has been possible to take three crops per year off the light irrigable land by following wheat with benniseed or groundnuts, and further attempts will be made next year to adjust the times of sowing so as to ensure that these crops are harvested under the most favourable conditions possible. The local variety of groundnuts has given a very heavy yield and may prove a useful crop under irrigation conditions. West Indian sugar cane showed itself markedly superior to the local cane both in yield and quality though all these canes suffered from a high flood in their later stages. Harvesting of some of the later dry season crops was facilitated because the first rains fell about a month later than usual.

A1. 1A-18A. *See* Tables 1 and 2.

WHEAT—RATE OF WATERING EXPERIMENT.

	Yield in lb. per acre.	Odds that difference is significant.
Mean of 9 plots watered at 14 day intervals ...	363	—
Mean difference of 4 plots watered at 7 day intervals	+ 3±79·2	Nil.
„ „ „ 3 „ „ „ 21 „ „	+28±91·4	Nil.

The results of this experiment help to confirm those of a similar one made last year, viz., that the rate of watering appears to make little difference to the yield of the crop. The heaviest yields were again obtained from the light soil plots.

A2. 1A—18A. *See* Table 3.

WHEAT—WATERING BY OBSERVATION.

Mean yield of all plots 484.6 lb. per acre.

In this block as in A1 the highest yields were obtained on the light soil plots, *i.e.*, towards 18A. In this and the previous experiment and the two experiments on these plots last year, the crop is definitely poor on the heavier soils. This may be due to lack of aeration in the heavy soil while the lighter soil receives an adequate supply of air. It is hoped next year that by postponing the preparation of the heavy soils until the land has dried an improved yield will result.

A1. 14A—22B. *See* Table 4.

GROUNDNUTS.

Mean yield of all plots—961 lb. per acre, unthreshed.

Groundnuts were sown here after wheat in an attempt to get three crops off the land in the year. Seed of a number of varieties obtained from the Botanist was sown on ridges at 13 inch spacing, one seed to a hole. In their later stages they suffered from excess water and had to be harvested before they were ready, as water was then standing in the lowest lying plots, which therefore gave the lowest yield. Some of the nuts had rotted and some had been attacked by fungus, but the following six varieties appeared able to withstand these conditions:—

Spanish Peanut.
Spanish Peanut, Strain 5.
,, ,, Strain 10.
U.S.A.
Philippine Pink.
Damberta.

The first five are definitely known to be early types, but Philippine Pink has longer and more attractive nuts.

A2. 15A—20B. *See* Table 5.

BENNISEED.

Mean yield of all plots— 224 lb. per acre.

Like the last experiment this was an attempt to grow three crops per annum on the same land. The seed was sown on ridges in clumps of about ten seeds at intervals of a foot, and subsequently thinned to three plants per stand. A good yield was obtained but much

trouble was experienced in drying the pods during the wet season. The crop was affected by a sort of witch's broom disease—a shortening of the internodes in the flowering region and a production of abnormal leaves. This caused a very appreciable reduction in the yield, as after a plant had been attacked it produced no more seed.

Sugar Block 1—6. *See* Table 6.

Sweet Potatoes.

Mean yields per acre.

On Banks	14,832 lb.
,, Ridge	8,456 lb.
,, Flat	2,620 lb.

The banks gave the best yield and the flat the worst. It may be noted however that the soil gets heavier from plot 1 to plot 6 and probably the sweet potatoes prefer the lighter soil. The banks received most water and the flat least but it is doubtful whether the difference in the amount of water applied has much effect on the subsequent yield. The roots were attacked by a caterpillar which is a well known local pest of sweet potatoes but this had little effect on the yield.

Sugar Block 7—12. *See* Table 7.

Sugar Cane

Mean yield per acre of local canes ... ... 7,800 lb.
,, ,, ,, ,, ,, West Indian canes 22,232 lb.

This sugar cane was established with difficulty and a long time elapsed before it grew really well. At the end of June all plots received a dressing of dung equivalent to three tons per acre. Owing to the rise in the water table the cane passed its last three months with the entire root system under water. The local canes were the more promising at first but after a time the West Indian took the lead, and finally produced about three times the yield of the Kworre cane. The sugar content also was superior. It does not, of course, follow that the difference would be so great under drier conditions, but it appears that the West Indian cane is able to tolerate flood conditions better than the local variety.

E2. 8A—16B. *See* Table 8.

Groundnuts.

Mean yield per acre of all plots, 2, 104 lb., unthreshed.

This was a most successful crop, in spite of considerable damage to the young seedlings by crows. Flowering was somewhat prolonged by the advent of the rains, but it was possible

to harvest the crop before the land became too wet. It seems likely that groundnuts will prove a very profitable crop on the lighter irrigable land in the fadama.

(B) *Wet Season Cropping.*—The wet season cropping this year was not very successful on account of locusts and because of the bursting of the Marabawa Bank and the subsequent flooding.

The first swarms of locusts appeared towards the end of May and swarms passed over on an average every three days until the middle of July. In spite of attempts to drive them off they usually took their toll of the young rice seedlings in passing, in several instances eating the whole crop down to the ground. One or two small bands of hoppers were destroyed before they caused any trouble. Further swarms of adult locusts appeared in September and October but did not do a great deal of damage. The rice recovered remarkably well from the locust attacks and only two blocks had to be resown, though in one or two other blocks what was believed to be the crop turned out to be volunteer rice.

The season was notable for the long hot period and the lateness of the first rains. *See* Table 12. The greatest fall was three inches on July 23rd, and the total for the year is somewhat above the average: 27.85 inches as compared with 24.53. The early part of the rains was remarkable for the dry East wind which lowered the humidity and caused the land to dry very quickly after watering. A hard crust then formed on the top of the soil and hindered germination, so that the land in some fields had to be watered occasionally to soften the crust, although there was ample water for growth in the lower layers of the soil.

The drains were full for the first time on July 14th. The level of water rose and fell considerably according to the rainfall, but there was a general rise up to September 4th when the reduced level was 33 feet 11 inches the ground level being from 31 to 32 feet. On August 4th the main drain was closed as most of the rice required a greater depth of water. The local rainfall had little or no effect on the water level after the end of August.

On September 20th the Marabawa Bank burst owing to the sudden rise of the Rima River to an unprecedented level. Water rushed through the breach and made its way to the Government Farm, which occupies a rather low-lying region inside the bank, and after two days all our rice was submerged. Strenuous efforts were made to repair the breach which widened to about 40 feet but owing to the force of the water these proved unavailing and the attempts had to be abandoned after a week. By September 23rd the

level had risen to reduced level 37 feet and on that evening the bank burst in two places near the outlet owing to the pressure of water from inside. This released some of the water and caused a return to the conditions obtaining before the bank was built.

The rice had just headed and was starting to ripen when the burst occurred. Its effect was to destroy most of these first formed heads. Some of the latent axillary buds then developed into shoots, thus causing branches to appear at the nodes half-way up the stems. These developed heads and produced the major part of the crop. Much of the rice completely lodged and adventitions roots and tillers, formed at the nodes lying on the ground. The net result was that rice harvest was very late and the yield of the crop was less than half what was expected.

In spite of these difficulties a few useful results have been obtained. Volunteer rices are still causing considerable trouble and make it very difficult to get reasonable pure crops of any of the varieties. It is now thought probable that in manured plots many of these gain entrance through the dung. Further, it appears probable that watering before ploughing kills out a large proportion of the volunteers. The Indian method of cultivation, by puddling and transplanting, gave very promising results.

The mean cost per acre of growing this year's rice crop was £5 17s. 11d., equivalent to 202 man-days per acre (@ 7d. per man-day). All yields are expressed below as unhusked paddy.

WET SEASON CROPPING, 1930.

A1. 1A—13B. *See* Table 9.

RICE—YIELD TRIAL.

Mean yield of 12 control plots (Jatau) ... ... 834·7 lb. per acre.
Mean difference of 11 Treatments (Guiana Creole) ... −759·3±47·9 „ „
Odds that difference is significant = ∞ : 1

This block is laid down permanently to rice in the rains and wheat in the dry season. in order to discover what effect this combination has in exhausting the land. This year Guiana Creole was tried against Jatau. The preparatory cultivation for this block was ploughing followed by levelling and puddling. Since the yield of Jatau was comparatively good for the season it appears possible that broadcasting may be successfully combined with puddling. Added to this is the fact that the weeding costs were considerably reduced. The average cost of weeding per acre on the whole farm was £2 0s. 4d.. while on this block it was only

£1 6s. 10d.,—a reduction of about one-third. The crop suffered much from locust damage in the early stages, especially the Guiana Creole, but almost from the beginning Jatau made the stronger growth. It would seem as if Guiana Creole was a more tender plant, and more susceptible to adverse conditions. This being so, it may be advisable in future to sow it at a heavier rate. The sudden rise of the flood when the Marabawa Bank burst destroyed any hope of a good yield, but even so the Jatau of this block gave one of the best yields on the farm.

B2. 1A—13A. *See* Table 10.

Rice—Cultivation Experiment.

Mean yield of 12 Standard plots = 688·0 lb. per acre.
„ difference of 6 Kaptu plots = +93·3±129·8 lb. per acre.
„ „ „ 5 Ploughed late plots = +96·0±142·2 lb. per acre.
Odds that differences are significant 3 : 1 in both cases.

The object here was to test three different methods of preparing rice land, viz., early ploughing and levelling just after rice harvest, kaptu in March and late ploughing just before sowing. The early ploughing was the standard. There was no significant difference in yield between any of the treatments but against the early ploughing and the kaptu must be set the fact that these plots required to be hoed before it was possible to sow the rice, as the ground was so hard and overrun with weeds. No difference was observed in the weed flora of the plots which might have been occasioned by the different treatments.

(C) Bank. 1—15. *See* Table 11.

Rice Yield Trials.

This block was laid out during the dry season and divided in five separate acres by large banks. Each acre was then levelled, and divided into three by low bunds. As each acre was on a different level, it was anticipated that when the flood took control of the water conditions, it would be possible to have rice growing in different heights of water, so that the effect of this on the different rice varieties could be observed. A yield trial was laid out using Fisher's Random Block arrangement, six varieties being repeated three times within each acre. The same layout was adopted in each of the five acres so that each one formed a separate yield trial.

The land received a very thorough levelling and puddling during the dry season and was watered before transplanting. The seedlings in the nursery had suffered much damage from locusts and there were not sufficient of the varieties Guiana Creole, Guiana 75 and Maliya there to transplant all the five acres, but seedlings were obtained from other blocks in the farm. Whilst this, of course, rather tends to spoil the statistical accuracy of the experiment, nevertheless useful indications were gained. The growth of the rice was very uneven, some varieties being very good in one plot and very poor in another. This occurred in patches and is probably due to soil difference caused by the levelling. The locust damage also made it impossible to get the rice transplanted at the proper time, and it was nearly a month late: consequently it was hard pressed to keep above the rising water. The exotic varieties Guiana Creole, Guiana 75 and Maliya appeared to do best at first but they suffered most from the rising water table and soon the Birnin Kebbi varieties Tattara and Babban Fari, which had originally been the poorest, showed themselves superior.

All the water which was let on to the plots from the distributary was measured and pegs were driven into the centre of each plot (*i.e.*, each ¼ acre) and the height of water measured daily. These showed that there was little difference in level between the first four acres but in the fifth acre (plots 13-15) there were about six inches more water than in the rest. It was noticeable the Birnin Kebbi rices did best in this acre from the very start.

Results :—

	Guiana Creole.	Guiana 75.	Maliya.	Jatau.	Bubban Farin.	Tattara.	Mean.	Standard Error.
Plots 1–3 Yields in lb. per acre	537	590	1,352	1,161	1,248	693	930	276
Yield per cent.	57·8	63·5	145·3	124·8	134·2	74·5	100	29·7

Maliya is significantly better than Guiana Creole and Guiana 75.

Plots 4–6 Yields in lb. per acre	303	451	321	355	650	702	464	200
Yield per cent.	65·5	97·2	69·0	76·6	140·0	151·2	100	43·1

No significant result.

Plots 7–9 Yields in lb. per acre	87	95	295	364	867	381	347	152·3
Yield per cent.	25·0	27·4	85·0	105	250	110	100	43·8

Bubban Farin beats all the others.

Plots 10–12 Yield in lb. per acre ...	28	173	156	208	459	494	254	123·8
Yield per cent.	11	68·2	61·4	81·9	181	195	100	48·7

Tattara significantly better than Guiana Creole and Maliya.
Bubban Farin significantly better than Guiana Creole.

Plots 13–15 Yield in lb. per acre ...	121	321	355	...	806	927	506	96·7
Yield per cent.	23·9	63·4	70·0	...	159	183	100	19·1

Tattara significantly better than Guiana Creole, Guiana 75 and Maliya.
Bubban Farin significantly better than Guiana Creole, Guiana 75 and Maliya.

(C) OTHER INFORMATION.

Buildings.—A new permanent office was built and gives great satisfaction.

Cattle.—There are now 19 cattle of which five are young stock undergoing training.

The scab disease " kirchi " reported last year gave trouble again during the rains and a few beasts were slaughtered on account of it as they were unable to work and seemed incurable.

DRY SEASON, 1929–30.

TABLE No. 1.

SOKOTO WHEAT—RATE OF WATERING EXPERIMENT.

Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
A1. 1*a*	Non-Experimental	336	
b	14 day	368	
2*a*	Non-Experimental	336	
b	7 day	360	+ 8
3*a*	Non-Experimental	216	
b	14 day	336	
4*a*	Non-Experimental	408	
b	21 day	384	+ 84
6*a*	Non-Experimental	256	
b	14 day	264	
7*a*	Non-Experimental	200	
b	7 day	176	− 76
8*a*	Non-Experimental	240	
b	14 day	240	
9*a*	Non-Experimental	256	
b	21 day	248	+ 8
10*a*	Non-Experimental	288	
b	14 day	240	
11*a*	Non-Experimental	240	
b	7 day	272	+ 56
12*a*	Non-Experimental	208	
b	14 day	192	
13*a*	Non-Experimental	224	
b	21 day	336	− 8
14*a*	Non-Experimental	408	
b	14 day	496	
15*a*	Non-Experimental	526	
b	7 day	656	+ 24
16*a*	Non-Experimental	704	
b	14 day	768	
17*a*	Non-Experimental	960	
b	14 day	1,024	
18*a*	Non-Experimental	1,136	

Increase or decrease caused by 7 day watering as compared with 14 day watering.

+ 8
− 76
+ 56
+ 24

Mean + 3·0 ± 79·2 lb. per acre.

Increase or decrease caused by 21 day watering as compared with 14 day watering.

+ 84
+ 8
− 8

Mean + 28·0 ± 91·4 lb. per acre.

TABLE No. 1—continued.

Variety :—Sokoto Wheat.
Sown :—14th December, 1929.
Harvested :—25th to 31st March, 1930.
Previous Crop :—Rice — Guiana Creole.
Seed-Rate :—96 lb. per acre.
Size of Plots :—1/16th acre.
Cost of Crop in man-days per acre :—81.

Root—mean—square—difference between pairs of neighbouring controls = 158·3 lb. per acre.

TABLE No. 2.

SOKOTO WHEAT: RATE OF WATERING EXPERIMENT.

AMOUNT OF WATER IN CUBIC FEET APPLIED TO EACH 1/16TH ACRE PLOT.

	Cubic feet.	No. of Waterings.
A1. 1*a*—4*b*	No measurement available.	
6*a*	858	1
b	4,862	5
7*a*	1,630	2
b	5,792	9
8*a*	1,695	2
b	3,223	5
9*a*	1,501	2
b	3,699	3
10*a*	1,435	2
b	3,308	5
11*a*	1,498	2
b	5,240	9
12*a*	1,741	2
b	2,997	5
13*a*	1,053	2
b	2,827	3
14*a*	1,701	2
b	3,158	5
15*a*	1,762	2
b	5,501	9
16*a*	1,887	2
b	3,646	5
17*a*	893	2
b	3,961	5
18*a*	1,828	2

TABLE No. 3.

SOKOTO WHEAT: WATERING BY OBSERVATION TEST.

Plot.	Yield per acre in lb.	Volume of water applied in cubic feet per plot (1/16th acre.)	No. of Waterings.
A2. 1*a*	256	No measurement available.	
b	296		
2*a*	336		
b	296		
3*a*	304		
b	336		
4*a*	336		
b	432		
Drain.			
6*a*	240	3,034	4
b	320	2,460	4
7*a*	368	3,285	4
b	432	2,428	4
8*a*	536	3,638	4
b	456	2,038	4
9*a*	512	2,403	4
b	640	2,368	4
10*a*	632	1,942	4
b	496	3,148	4
11*a*	384	2,135	4
b	376	2,378	4
12*a*	320	2,572	4
b	304	4,152	5
13*a*	384	3,115	5
b	352	4,101	6
14*a*	416	4,264	7
b	480	3,220	7
15*a*	640	4,156	7
b	672	4,403	7
16*a*	912	5,179	7
b	816	3,289	7
17*a*	936	4,659	7
b	824	4,428	7
18*a*	952	6,470	7

Variety sown :—Sokoto Wheat.

Previous Crop:—Fallow.

Sown :—16th December, 1929.

Seed-Rate :—96 lb. per acre.

Harvested :—25th to 31st, March, 1930.

Size of Plots :—1/16th acre.

Cost in man-days per acre :—83.

TABLE No. 4.

GROUNDNUTS AFTER WHEAT (OR FALLOW).

Plot.		Yield per acre in lb.	Variety.	Volume of water in cubic feet per plot (1/16th acre).
A1.	14*a*	352	Damberta	1,742
	b	528	Spanish Peanut Strain 10...	1,782
	15*a*	352	Philippine White	2,309
	b	528	Biu	1,823
	16*a*	624	Ceylon	3,443
	b	1,088	Spanish Peanut Strain 5 ...	2,471
	17*a*	1,072	Philippine Pink	2,916
	b	1,360	Basse	2,835
	18*a*	2,096	Spanish Peanut	4,941
	Distributary.			
	19*a*	1,600	U. S. A.	2,592
	b	1,168	Ceylon	3,078
	20*a*	1,632	Big Japan	2,957
	b	1,312	Damberta	2,552
	21*a*	400	Philippine White	2,552
	b	912	Spanish Peanut	1,985
	22*a*	624	Basse	2,633
	b	688	Philippine Pink	1,843

Dates of watering, 4th and 21st April, and 12th May, 1930.
Amount of rainfall until harvest, 18·37 inches.
Sown, 5th April, 1930.
Harvested, 8th and 11th August, 1930.
Previous Crop { 14*a*–18*a*, Wheat. / 19*a*–20*b*, Fallow.
Seed-Rate, 48 lb. per acre.
Size of plots, 1/16th acre.
Cost per acre in man-days, 125.

TABLE No. 5.

Benniseed after Wheat.

Plot.	Yield in lb. per acre.	Volume of water applied in cubic feet per plot (1/16th acre).
A2. 15*a*	96	1,947
b	144	1,973
16*a*	208	1,793
b	224	2,086
17*a*	224	1,671
b	168	1,914
18*a*	256	1,581
Distributary.		
19*a*	320	2,013
b	312	1,947
20*a*	256	1,767
b	264	1,914

Dates of Watering, 8th and 22nd April, and 12th May, 1930.
Amount of rainfall to harvest, 13·93 inches.
Variety, from Yandev.
Sown, 9th April, 1930.
Harvested, 28th July, 1930.
Previous Crops { 15*a*–18*s*., Wheat. / 19*a*–20*b*., Fallow.
Seed-Rate, 4 lb. per acre.
Size of plots, 1/16th acre.
Cost per acre in man-days, 68.

TABLE No. 6.

Sweet Potatoes.

Plot.	Treatment.	Yield per acre. in lb.	Volume of water applied in cubic feet per 1/8th acre plot.	No. of Waterings.
Sugar				
Block 1	Bank	14,888	17,589	15
2	Ridge	11,344	10,856	11
3	Flat	3,536	8,742	8
4	Bank	14,776	15,765	15
5	Ridge	5,568	10,331	11
6	Flat	1,704	8,417	8

Variety, Local.
Planted, 15th November, 1930.
Harvested, 7th and 8th May, 1930.
Previous Crop, Sweet Potatoes.
Size of plots, 1/8th acre.
Cost per acre in man-days, 552.

TABLE No. 7.

Sugar Cane : West Indian *Vs.* Local.

Plot.	Variety.	Yield per acre in lb.
Sugar Block 7	W. I. B. 208	18,560
8	Local	3,424
9	West Indian Mixed	21,728
10	Local	9,664
11	West Indian	26,408
12	Local	10,320

Varieties ... ... As above.
Planted ... ... Plots 7 and 9 (part). 15th January, 1930.
„ 8, 10 and 12. 18th „ „
„ 9 (part) and 11. 24th December, 1929.
Harvested ... ... Local 23rd October, 1930.
West Indian 29th and 30th October, 1930.
Previous Crop ... ... Sugar Cane.
Size of plots ... ... 1/8 acre.
Cost per acre in man-days ... 436.

TABLE No. 8.

Groudnuts.

Plot.	Yield in lb. per acre.
E2. 8*a*	1,792
8*b*	1,872
9*a*	2,576
9*b*	1,920
10*a*	2,304
10*b*	2,828
11*a*	2,170
11*b*	2,304
12*a*	2,192
12*b*	2,080
13*a*	2,096
13*b*	2,128
14*a*	1,872
14*b*	2,096
15*a*	1,968
15*b*	1,728
16*a*	2,080
16*b*	1,744

Variety ... ... Local.
Sown ... ... 21st January, 1930.
Harvested ... ... 12th July, 1930.
Previous Crop ... ... Masakwa.
Size of plots ... ... 1/16 acre.
Cost per acre in man-days... 204.

TABLE No. 9.

WET SEASON, 1930.

RICE AFTER WHEAT—GUIANA CREOLE *Vs.* JATAU.

Plot.		Variety.	Yield per acre in lb.	Increase (+) or decrease (−) compared with mean of adjacent controls.
A1.	1*a*	Guiana Creole	64	
	b	Jatau	784	
	2*a*	Guiana Creole	128	− 680
	b	Jatau	832	
	3*a*	Guiana Creole	128	− 784
	b	Jatau	992	
	4*a*	Guiana Creole	208	− 728
	b	Jatau	880	
Drain.	6*a*	Guiana Creole	8	− 816
	b	Jatau	768	
	7*a*	Guiana Creole	8	− 728
	b	Jatau	704	
	8*a*	Guiana Creole	16	− 704
	b	Jatau	736	
	9*a*	Guiana Creole	8	− 920
	b	Jatau	1,120	
	10*a*	Guiana Creole	112	− 920
	b	Jatau	944	
	11*a*	Guiana Creole	32	− 832
	b	Jatau	784	
	12*a*	Guiana Creole	160	− 632
	b	Jatau	800	
	13*a*	Guiana Creole	128	− 608
	b	Jatau	762	

Increase (+) or decrease (−) of yield of Guiana Creole plots as compared with that of Jatau plots, lb. per acre.

− 680
− 784
− 728
− 816
− 728
− 704
− 920
− 920
− 832
− 632
− 608

Mean − 759·27 ± 47·9

TABLE No. 9—continued.

Varieties ... ... As above.
Sown ... ... 26th May, 1930.
Harvested ... ... Jatau, 17th November, 1930.
Guiana Creole, 22nd December, 1930.
Previous Crop ... ... Wheat.
Seed-rate ... ... 96 lb. per acre (broadcasted).
Size of plots ... ... 1/16 acre.
Cost per acre in man-days... 168.
Root—mean—square—difference between neighbouring control plots = 151·9 lb. per acre.

TABLE No. 10.

RICE—CULTIVATION EXPERIMENT. ALBARKA KUMBE.

Plot.		Treatment.	Yield in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
B2.	1*a*	Standard	512		
	1*b*	Kaptu		672	+ 24
	2*a*	Standard	784		
	2*b*	Ploughed late		592	−192
	3*a*	Standard	784		
	3*b*	Kaptu		1,120	+288
	4*a*	Standard	880		
	4*b*	Ploughed late		1,072	+472
	6*a*	Standard	320		
	6*b*	Kaptu		592	+280
	7*a*	Standard	304		
	7*b*	Ploughed late		816	+248
	8*a*	Standard	832		
	8*b*	Kaptu		752	+ 24
	9*a*	Standard	624		
	9*b*	Ploughed late		656	− 64
	10*a*	Standard	816		
	10*b*	Kaptu		832	− 88
	11*a*	Standard	1,024		
	11*b*	Ploughed late		800	+ 16
	12*a*	Standard	544		
	12*b*	Kaptu		720	+ 32
	13*a*	Standard	832		

Increase (+) or decrease (−) of "Kaptu" plots compared with Standards.	Increase (+) or decrease (−) of "ploughed late" plots compared with Standards.
+ 24	− 192
+ 288	+ 472
+ 280	+ 248
+ 24	− 64
− 88	+ 16
+ 32	
Mean + 93·3 ± 129·8	Mean + 96 ± 142·2

Variety ... ... Albarka Kumbe.
Sown ... ... 27th May, 1930.
Harvested ... ... 6th December, 1930.
Previous Crop ... ... Rice.
Seed-rate ... ... 96 lb. per acre.
Size of plots ... ... 1/16 acre.
Cost per acre in man-days ... 301.
Root—mean—square—difference between neighbouring control plots = 318 lb. per acre.

TABLE No. 11.

RICE VARIETY TRIALS—BLOCK C, YIELD PER ACRE.

GC. 1,274	G 75. 988	J. 1,378	BF. 1,222	M. 1,586	J. 1,404	M. 1,352	BF. 1,586	T. 1,352
M. 1,118	BF. 936	T. 520	T. 208	GC. 182	G 75. 208	GC. 156	J. 702	G 75. 572
GC. 156	G 75. 104	J. 52	BF. 130	M. Nil	J. 26	M. 156	BF. 754	T. 910
M. 806	BF. 1,066	T. 624	T. 572	GC. 234	G 75. 390	GC. 520	J. 988	G 75. 858
GC. 182	G 75. 208	J. 416	BF. 1,118	M. 286	J. 416	M. 390	BF. 1,144	T. 858
M. 208	BF. 338	T. 26	T. 260	GC. 26	G 75. 26	GC. 52	J. 260	G 75. 52
GC. 26	G 75. 130	J. 234	BF. 494	M. 208	J. 52	M. Nil	BF. 182	T. 52
M. 260	BF. 702	T. 520	T. 910	GC. 26	G 75. 208	GC. 52	J. 338	G 75. 182
GC. Nil	G 75. 130	J. Nil	BF. 754	M. 286	J. 52	M. 494	BF. 728	T. 650
M. 286	BF. 936	T. 884	T. 1,248	GC. 234	G 75. 468	GC. 130	J. 156	G 75. 364

Key to plots

3	2	1
6	5	4
9	8	7
12	11	10
15	14	13

TABLE No. 11—continued.

Varieties	GC = Guiana Creole.
	G 75 = Guiana 75.
	J = Jatau.
	M = Maliya.
	BF = Babban Fari.
	T = Tattara.
Transplanted	17th July, 1930.
Harvested	Between 27th November and 30th December, 1930.
Previous Crop	Fallow on plots 1–9.
	Rice on plots 10–15.
Size of Plots	$\frac{1}{3}$ acre, each containing 6 sub plots of 1/26 acre.
Cost per acre in man-days ...	177.

TABLE No. 12.

KWORRE : MONTHLY RAINFALL IN INCHES, 1926–30.

Month.	1926.	1927.	1928.	1929.	1930.	MEANS.
January ...	...	...	...	...	...	...
February ...	...	...	...	...	...	...
March	...	...	...	...	...	...
April	1·17	0·09	0·35	0·06	...	0·33
May	2·43	2·17	0·25	1·51	1·42	1·56
June	5·35	0·98	3·63	4·63	3·09	3·54
July	4·21	9·00	4·16	7·65	10·93	7·19
August ...	3·84	9·82	13·16	8·77	9·60	9·04
September ...	1·39	3·40	2·54	2·46	2·63	2·48
October ...	...	1·46	0·12	0·20	0·18	0·39
November ...	...	...	...	...	...	...
December ...	...	...	...	...	...	...
Totals ...	18·39	26·92	24·21	25·28	27·85	24·53

ANNUAL REPORT, YANDEV PLANTATION, 1930.

The following officers were in charge during 1930 :—

Mr. I. E. James, B.SC., from 1st January to 15th August.

,, J. F. Ward, M.A., from 16th August to 31st December.

The four years' rotation originally laid down in 1927, as explained in the Annual Reports for 1928 and 1929, has completed the first circle. Some useful information has been obtained and there are indications that the fertility of the soil has been well maintained.

Two subsidiary rotations are now in their second and third years.

The year's rainfall compares closely with the average of the four years, 1927-30. Precipitation was evenly distributed from mid-April to the second week in November.

Under these favourable conditions the crop yields were very good in spite of locust damage at the beginning of the season.

Numerous experiments with times of planting various crops have shown definite results over three and four seasons. New methods of harvesting benniseed have been devised and have proved a satisfactory improvement. The information thus obtained is being incorporated in the routine plantation practices, and it is hoped that some of these will be adopted by local farmers.

YAMS—TIMES OF PLANTING.

(*See* Table No. 1.)

	Yield in lb. per acre.	Odds that difference is significant.
Average yield 10 plots planted 1st January	13,214	—
Average increase 5 plots planted 17th February	+542±668	4 : 1
Average decrease 4 plots planted 3rd April	−82·5±597	—

This experiment shows no great difference in yield due to altering the date of planting. This may have been caused by the regularly and evenly distributed rainfall and by the late commencement of the dry season—the second week in November. Under less favourable conditions yams planted after the middle February have given significantly lower yields than earlier planted yams.

Yams—Variety Trial.

(*See* Table No. 2.)

	Yield in lb. per acre.	Odds that difference is significant.
Average yield 10 plots "Hard" yams ...	7,580	—
Average increase 9 plots "Water" yams ...	+2,233±692	4,350 : 1

These two varieties were planted on 29th and 30th January. Similar proportions of head-yams and seed-yams were planted for each variety. The "Water" yams have given a significantly heavier yield than the "Hard" yams. Owing to the high percentage of water in the former variety, the superiority from a food value point of view is not so striking.

Account was taken of the infestation by the yam beetle (Heteroligus claudius) and gave the following figures:—

Variety	*per cent Infestation.*
Water yam	26.4%
Hard yam	49.0%

Gero & Guinea Corn—Times of Planting Guinea Corn Through Gero.

(*See* Table No. 3.)

	Yield of gero and guinea-corn in lb per acre. (grain.)	Odds that difference is significant.
Average yield 10 plots guinea-corn planted 6 weeks after gero	1,353	—
Average decrease 5 plots guinea-corn planted 9 weeks after gero ...	−360±105	4,350 : 1
Average decrease 4 plots guinea-corn planted 12 weeks after gero	−592±118	∞ : 1

Favourable rains encouraged a good stand of gero, the yield of which, was in all probability about halved by locust attacks as it was coming into ear. In spite of this high yields and significant results have been obtained and they compare favourably with the results of similar experiments carried out in previous seasons. Sowing guinea corn through gero has given better yields than sowing after harvesting the gero The latter method is the common practice carried out by the Munshis in the neighbourhood of the plantation. Should the land be heavily infested with Striga senegalensis, however, this semi-parasite may take such a strong hold on the early sown guinea corn as to reduce the yield below that of later sowings.

Guinea Corn—Times of Planting.

(*See* Table No. 4.)

	Yield in lb. per acre (grain).	Odds that difference is significant.
Average yield 10 plots	751	—
Average decrease 5 plots sown one month later	−193±50·5	7 4,350 : 1
Average decrease 4 plots sown two months later	−151±56·5	7 160 : 1

The ten plots of guinea corn sown on the 1st May have given heavier yields than guinea corn sown at later dates. The block on which this experiment was carried out was comparatively free from Striga senegalensis and the May-sown guinea corn maintained its lead. This experiment has been carried out for three years and the results have given the same general indications. Guinea corn, grown as a sole crop, gives a lower return per man-day than a combined crop of gero and guinea corn.

Groundnuts—Variety Trial.

(*See* Table No. 5.)

	Yield in lb. per acre of decorticated nuts.	Odds that difference is significant.
Average yield 6 plots Munshi ...	1,027	—
Average decrease 5 plots Yola " A " ...	−397±62	∝ : 1

The groundnuts were sown in April, germinated well and grew most satisfactorily throughout the season. The Munshi variety of groundnut was superior in germination and in yield. Yola " A " variety has been grown at Yandev for three seasons but does not compare favourably with the local variety.

Both varieties were healthy and free from " Rosette " disease.

Groundnuts—Grown on Three Feet Ridges *versus* on Beds.

(*See* Table No. 6.)

	Yield in lb. per acre of decorticated nuts.	Odds that difference is significant.
Average yield 5 plots ridges	741	—
Average decrease 4 plots beds ...	−175±82	43 : 1

The groundnuts were sown in April on rather heavy soil, which was infested with Sword grass (Imperata sp.). The plants were so spaced that an area of three square feet was devoted to each stand on both ridges and beds. Under the unfavourable conditions of the land, the groundnuts on beds do not compare favourably with

those grown on ridges. A similar experiment was carried out in 1929 (*see* Report for that year), and the groundnuts grown on beds gave better results.

Benniseed—Method of Harvesting.

(*See* Table No. 7.)

	Yield in lb. per acre.	Odds that difference is significant.
Average yield 10 plots harvested Munshi method	558·6	—
Average decrease 9 plots stooked ...	−30·4 ± 16·1	34 : 1

The benniseed was sown in April and grew exceptionally well. The experiment has been carried out for three years and in each season very little difference in yield has been obtained. On the money side stooking has been very much the cheaper of the two methods of harvesting.

The average total cost of cultivation in man-days per acre over three years is as follows :—

Munshi method	80.3 M.D.
Stooking method	50.8 M.D.

Benniseed—Method of Preparation and of Sowing.

(*See* Table No. 8.)

	Yield in lb. per acre.	Odds that difference is significant.
Average yield 10 plots on 3 feet ridges ...	484·2	—
Average increase 9 plots broadcasted ...	+10·1 ± 30·6	—

This experiment has been carried out for three years and shows that the yield of benniseed does not differ appreciably under the two treatments. The cost of broadcasting the seed, in accordance with the native practice, is considerably cheaper than preparing ridges and dibbling in the seed. But if the crop is not carefully weeded, the cost of harvesting broadcasted benniseed may become sufficiently large to counteract the saving obtained by broadcasting. This occurred in 1929.

The total cost of cultivation in man-days per acre for the three years 1928-29 and 30 are compared below :—

METHOD.	COST MAN-DAY PER ACRE.		
Year.	1928.	1929.	1930.
On three foot ridges	95	58	77·5
Broadcasted	78	82·5	61·5

In 1928 and 1930 the benniseed under both treatments were weeded once; in 1929 the broadcasted benniseed was not weeded.

Benniseed—Size of Ridges.

(*See* Table No. 9.)

	Yield in lb per acre.	Odds that difference is significant.
Average yield 10 plots on 3 feet ridges ...	153·8	—
Average decrease 9 plots on 6 feet ridges	−30·4±11·7	160 : 1

The benniseed was sown late (10th May) and became attacked during the flowering period by aphis and a ' gall-forming ' fly, as well as by mildew. These pests considerably reduced the yield, but were equally prevalent throughout the block.

This experiment has been carried out for three seasons; the general tendency is for the benniseed on the three foot ridges to give a heavier yield than when grown on six foot ridges. In each year the benniseed was sown in three rows on six foot ridges and in two rows on the smaller ridges.

Cotton—Variety Trial.

(*See* Table No. 10.)

	Yield in lb. per acre, seed cotton.	Odds that difference is significant.
Average yield 10 plots Munshi cotton ...	117·2	—
Average increase 9 plots Ishan A ...	+78·2±15·2	∞ : 1

This experiment has been carried out over a number of years. This year Ishan ' A ' has given significantly heavier yields than Munshi cotton and confirms the results obtained in 1929. The Ishan cotton is liable to have a greater proportion of dirty lint than Munshi, and especially so when grown near Allen, which attracts stainers. Since 1928 Allen has been discarded and is no longer grown on the plantation.

The cotton was sown in favourable weather and a very satisfactory stand was obtained. Growth was excellent during the earlier part of the season, but at the beginning of October the whole block was invaded by Bacterium malvacearum, which produced advanced symptoms of Angular leaf-spot and Black-arm. A large proportion of the leaves were shed. Jassids and Stainers were present but caused only relatively little damage.

The Ishan plants were noticeably more even than those of Munshi cotton.

Ishan A Cotton—Times of Sowing.

(*See* Table No. 11.)

	Yield in lb. per acre of seed cotton.	Odds that difference is significant.
Average yield 10 control plots sown 16th June	228·8	—
Average decrease 5 plots sown 1st July ...	−40·4±18·1	43 : 1
Average decrease 4 plots sown 17th July	−91·3±20·3	∞ : 1

During 1928 and 1929 experiments have shown that both Ishan A ' and Munshi cotton have responded to early sowing. This year the sowing was commenced on 16th June and continued at two fortnightly intervals, and the results again show that the early sown cotton gives a much better yield. This block of cotton remained relatively free from pests throughout the season. Favourable weather encouraged good growth from the time of sowing and a very satisfactory stand was obtained on all plots.

TABLE No. 1.

Yams—Times of Planting.

No. of Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.	
Block B9.				
Plot 1	1/1/30	12,556		
2	17/2/30	11,426	− 1,446	
3	1/1/30	13,188		
4	3/4/30	13,408		− 72
5	1/1/30	13,772		
6	17/2/30	14,372	+ 288	
7	1/1/30	14,396		
8	3/4/30	12,798		− 2,084
9	1/1/30	15,368		
10	17/2/30	15,946	+ 1,388	
11	1/1/30	13,748		
12	3/4/30	15,068		+ 1,386
13	1/1/30	13,616		
14	17/2/30	18,088	+ 4,216	
15	1/1/30	14,128		
16	3/4/30	13,474		− 440
17	1/1/30	11,940		
18	17/2/30	12,748	+ 2,064	
19	1/1/30	9,428		
20	1/1/30	11,542	Non-experimental	

Each plot ¼ acre. Ridges 6 feet apart. Single sets 2 feet apart. Harvested. 23rd to 28th January, 1931.

Average yield of 10 controls plots ... ... 13,214 lb. per acre nett.

Average increase 5 plots planted 17th February ... + 542 ± 668 lb.

Average decrease 4 plots planted 3rd April ... ... −82·5 ±597 lb.

Root—mean—square—difference between neighbouring control plots = 1,336 lb.

TABLE No. 2.

YAMS—VARIETY TRIAL.

No. of Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (—) compared with mean of adjacent controls.
Block B1.			
Plot 1	Hard	8,224	
2	Water	8,372	+ 1,771
3	Hard	4,978	
4	Water	12,272	+ 4,910
5	Hard	9,746	
6	Water	8,652	— 413
7	Hard	8,384	
8	Water	9,988	+ 2,089
9	Hard	7,414	
10	Water	10,040	+ 2,460
11	Hard	7,746	
12	Water	8,476	+ 790
13	Hard	7,626	
14	Water	12,444	+ 4,499
15	Hard	8,264	
16	Water	8,236	+ 684
17	Hard	6,840	
18	Water	10,032	+ 3,313
19	Hard	6,598	
20	Hard	9,102	Non-experimental

Each plot $\frac{1}{4}$ acre. Ridges 6 feet apart. Single sets 2 feet apart.

Planted 29th, 30th January, 1930. Harvested 8th, 9th January, 1931.

Average yield 10 plots "Hard" yams ... ... 7,580 lb. per acre nett.

Average increase 9 plots "Water" yams ... ... +2,233±692 lb.

Root—mean—square—difference between neighbouring control plots = 2,075 lb.

Average percentage of tubers damaged by the yam beetle, Heteroligus claudius.

Hard yams ... ... 49·0%.

Water yams ... ... 26·4%.

TABLE No. 3.

GERO AND GUINEA-CORN—TIMES OF PLANTING GUINEA-CORN THROUGH GERO.

No. of Plot.	Treatment.	Yield in lb. per acre of grain.			Increase (+) or decrease (−) compared with mean of adjacent controls.
		Gero.	Guinea-corn.	Total.	
Block C 11.					
Plot 1	6 weeks after...	388	886	1,274	
2	9 „ „ ...	380	648	1,036	− 262
3	6 „ „ ...	360	962	1,332	
4	12 „ „ ...	390	324	714	− 610
5	6 „ „ ...	382	944	1,326	
6	9 „ „ ...	388	606	994	− 342
7	6 „ „ ...	376	970	1,346	
8	12 „ „ ...	340	394	734	− 657
9	6 „ „ ...	462	974	1,436	
10	9 „ „ ...	468	484	952	− 454
11	6 „ „ ...	416	960	1,376	
12	12 „ „ ...	402	300	702	− 607
13	6 „ „ ...	444	798	1,242	
14	9 „ „ ...	434	472	906	− 248
15	6 „ „ ...	462	624	1,086	
16	12 „ „ ...	628	268	896	− 496
17	6 „ „ ...	750	948	1,698	
18	9 „ „ ...	726	340	1,066	− 494
19	6 „ „ ...	518	904	1,422	
20	6 „ „ ...	302	812		Non-experimental.

Each plot $\frac{1}{4}$ acre. Ridges 6 feet apart. Gero: on small heaps 2 feet apart in the furrow. Guinea-corn: Single row, stands 2 feet apart on the ridge top.

Gero:—Sown: 15th April. Harvested, 17th July, 1930.

Guinea-corn:—Sown, 29th May, 18th June, 11th July. Harvested, 15th and 16th December, 1930, 17th and 18th December.

Average yield of 10 control plots ... ... 1,353 lb. combined grain per acre.

Average decrease 5 plots sown 9 weeks after Gero ... -360 ± 105 lb.

Average decrease 4 plots sown 12 weeks after Gero ... -592 ± 118 lb.

Root—mean—square difference between neighbouring control plots = 236 lb.

Average percentage of grain to ear

Guinea-corn—29th May	... ...	67·6%.
18th June	... ...	65·3%.
11th July	... ...	56·0%.

TABLE No. 4.

GUINEA-CORN—TIMES OF PLANTING.

No. of Plot.	Treatment.	Yield in lb. acre of grain.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C 8.			
Plot 1	1/5/30	890	
2	3/6/30	468	−216
3	1/5/30	838	
4	2/7/30	604	− 306
5	1/5/30	982	
6	3/6/30	688	−138
7	1/5/30	872	
8	2/7/30	614	− 84
9	1/5/30	664	
10	3/6/30	316	−336
11	1/5/30	640	
12	2/7/30	482	− 219
13	1/5/30	762	
14	3/6/30	628	− 64
15	1/5/30	622	
16	2/7/30	732	+ 106
17	1/5/30	630	
18	3/6/30	410	−213
19	1/5/30	616	
20	1/5/30	570	

Each plot $\frac{1}{4}$ acre. Ridges 6 ft. apart. Two rows, stands 2 ft. apart staggered

Sown:—1st May — Harvested:—15th December, 1930

3rd June — 17th „ „

2nd July — 17th „ „

Average percentage of grain to ear.

Sown 1st May, 1930 ... ... 59·5%

„ 3rd June, 1930 ... ... 59·5%

„ 2nd July, 1930 ... ... 59·6%

Average yield 10 plots sown 1st May, 1930 = 751 lb. grain per acre.

Average decrease 5 plots sown 3rd June, 1930 = — 193 ± 50·5 lb.

Average decrease 4 plots sown 2nd July, 1930 = — 151 ± 56·5 lb.

Root—mean—square—difference between neighbouring control plots=113 lb.

TABLE No. 5.

GROUNDNUTS—VARIETY TRIAL.

No. of Plot.	Treatment.	Yield in lb. acre decorticated nuts.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C2.			
Plot 1	Munshi	1,262	
2	Yola 'A'	776	− 354
3	Munshi	1,098	
4	Yola 'A'	670	− 351
5	Munshi	944	
6	Yola 'A'	606	− 357
7	Munshi	982	
8	Yola 'A'	422	− 548
9	Munshi	958	
10	Yola 'A'	562	− 377
11	Munshi	920	

Each plot ¼ acre. Ridges 3 feet apart. Two rows, stands 2 feet apart, and staggered.
Decorticated seed sown at the rate of two per hole.
Sown, 18th April, 1930. Harvested, 18th–30th August, 1930.
Average yield of 6 control plots = 1,027 lb. decorticated nuts per acre.
Average decrease of 5 plots Yola 'A' = − 397 ± 62 lb.
Root—mean—square—difference between neighbouring control plots = 139 lb.
Percentage of kernels to undecorticated groundnuts
Munshi ... ... 53·5%
Yola 'A' ... ... 43·0%

TABLE No. 6.

GROUNDNUTS—3-FOOT RIDGES *versus* BEDS.

No. of Plot.	Treatment.	Yield in lb./acre. decorticated nuts.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C 2.			
Plot 11	3-foot ridges	920	
12	Beds	510	−308
13	3-foot ridges	716	
14	Beds	538	−108
15	3-foot ridges	576	
16	Beds	500	−111
17	3-foot ridges	646	
18	Beds	574	−174
19	3-foot ridges	850	
20	3-foot ridges	686	Non-experimental

Each plot ¼ acre. Ridges 3 ft. apart.
Beds 11 ft. wide and 1 foot apart.
Decorticated seed sown at the rate of two per hole, one stand to each 3 sq. ft.
Sown, 22nd April, 1930. Harvested, 18th to 30th August, 1930.
Average yield of 5 control plots = 741 lb. of decorticated nuts per acre.
Average decrease of 4 plots on Beds = − 175 ± 82 lb.
Root—mean—square difference between neighbouring control plots = 164 lb.

TABLE No. 7.

Benniseed—Method of Harvesting.

No. of Plot.	Treatment.	Yield in lb./acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block A.2.			
1	Munshi Method	460	
2	Stooking	578	+ 69
3	Munshi Method	558	
4	Stooking	464	− 94
5	Munshi Method	558	
6	Stooking	508	− 41
7	Munshi Method	540	
8	Stooking	568	+ 20
9	Munshi Method	556	
10	Stooking	500	− 61
11	Munshi Method	566	
12	Stooking	532	− 70
13	Munshi Method	638	
14	Stooking	596	− 32
15	Munshi Method	618	
16	Stooking	552	− 45
17	Munshi Method	576	
18	Stooking	520	− 20
19	Munshi Method	516	
20	Munshi Method	Non-experimental	

Each plot $\frac{1}{4}$ acre. Ridges 3 feet apart. 2 rows stands 1 foot apart, 3–4 plants per stand.

Sown 24th April. Harvested 29th–30th July, 1930.

Average yield of 10 control plots = 558·6 lb. seed per acre.

Average decrease of 9 plots stooked − 30·4 ± 16·1 lb.

Root—mean—square—difference between neighbouring control plots 48·5 lb.

Cost of cultivation in man-days per acre.

Munshi Method	76·5
Stooking ...	50.

TABLE No. 8.

BENNISEED—METHOD OF PREPARATION AND OF SOWING.

No. of Plot.	Treatment.	Yield in lb./acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block A.3.			
Plot 1	Ridges	492	
2	Broadcast	500	− 21
3	Ridges	550	
4	Broadcast	568	+ 53
5	Ridges	480	
6	Broadcast	516	+ 24
7	Ridges	504	
8	Broadcast	548	+ 40
9	Ridges	512	
10	Broadcast	500	+ 20
11	Ridges	448	
12	Broadcast	294	− 240
13	Ridges	620	
14	Broadcast	586	+ 42
15	Ridges	468	
16	Broadcast	472	+ 53
17	Ridges	370	
18	Broadcast	504	+ 120
19	Ridges	398	
20	Ridges	Non-experimental	

Each plot $\frac{1}{4}$ acre. Ridges 3 feet apart. Sown in two rows stands 1 foot apart and staggered, 3–4 plants per stand.

Broadcasted on levelled land. Sown 23rd April. Once weeded 15th May. Harvested 28th–29th July, 1930.

Average yield of 10 control plots 484·2 lb. seed per acre.

Average increase of 9 plots broadcasted $+10{\cdot}1 \pm 30{\cdot}6$ lb.

Root–mean–square–difference between neighbouring control plots 91·9 lb.

Cost of cultivation in man-days per acre.

On 3 feet Ridges ...	77·5
Broadcasted ...	61·5

TABLE No. 9.

BENNISEED—SIZE OF RIDGES.

No. of Plot.	Treatment.	Yield in lb./ acre.	Increase (+) or decrease (−) compared with mean of adjacent controls
Block C.6.			
Plot 1	Three feet ridges	160	
2	Six feet ridges	112	− 50
3	Three feet ridges	164	
4	Six feet ridges	82	− 70
5	Three feet ridges	140	
6	Six feet ridges	124	− 26
7	Three feet ridges	160	
8	Six feet ridges	152	− 36
9	Three feet ridges	216	
10	Six feet ridges	152	− 38
11	Three feet ridges	164	
12	Six feet ridges	148	− 18
13	Three feet ridges	168	
14	Six feet ridges	152	− 16
15	Three feet ridges	168	
16	Six feet ridges	120	− 16
17	Three feet ridges	104	
18	Six feet ridges	100	− 4
19	Three feet ridges	104	
20	Three feet ridges	Non-experimental	

Each plot $\frac{1}{4}$ acre. Three rows on 6 feet ridges. Two rows on 3 feet ridges. Stands 1 foot apart, 3–4 plants per stand.

Sown 10th May. Harvested 13th August, 1930.

Average yield of 10 control plots = 153·8 lb. seed per acre.

Average decrease of 9 plots on 6 feet ridges − 30·4 ± 11·7 lb.

Root - mean—square—difference between neighbouring control plots = 35·2 lb.

TABLE No. 10.

COTTON—VARIETY TRIAL.

No. of Plot.	Treatment.	Yield in lb./acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B2.			
Plot 1	Munshi	244	
2	Ishan A	214	+ 31·5
3	Munshi	121	
4	Ishan A	179	+ 82
5	Munshi	73	
6	Ishan A	153	+ 81·3
7	Munshi	70·5	
8	Ishan A	171·5	+ 93
9	Munshi	96·5	
10	Ishan A	241·5	+ 144·3
11	Munshi	98	
12	Ishan A	198	+ 86·8
13	Munshi	124·5	
14	Ishan A	205	+ 82
15	Munshi	121·5	
16	Ishan A	159·5	+ 38
17	Munshi	121·5	
18	Ishan A	177	+ 65·3
19	Munshi	102	
20	Munshi	109	Non-experimental.

Each plot $\frac{1}{4}$ acre. Ridges 6 feet apart. 2 rows, stands 4 feet apart and staggered.

Sown; 16th June.

Harvested from 6th December, 1930, to 5th March, 1931.

Average yield 10 plots Munshi 117·2 lb. per acre.

Average increase 9 plots Ishan A + 78·2 ± 15·2 lb.

Root-mean-square-difference between neighbouring control plots = 45·7 lb.

Average percentage of dirty cotton to total yield.

Munshi	14·6%
Ishan A	12·7%

TABLE No. 11.

Ishan Cotton—Times of Planting.

No. of Plot.	Treatment.	Yield in lb./acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.	
Block C1				
Plot 1	16/6/30	272·5		
2	1/7/30	235·5	− 49·5	
3	16/6/30	295·5		
4	17/7/30	169		− 83·5
5	16/6/30	209·5		
6	1/7/30	212	+ 1·3	
7	16/6/30	213		
8	17/7/30	112		− 105·2
9	16/6/30	221·5		
10	1/7/30	177	− 70·5	
11	16/6/30	273·5		
12	17/7/30	161		− 83·5
13	16/6/30	215·5		
14	1/7/30	147	− 56·5	
15	16/6/30	191·5		
16	17/7/30	104		− 93
17	16/6/30	202·5		
18	1/7/30	171	− 27	
19	16/6/30	193·5		
20	16/6/30	213		

Each plot $\frac{1}{4}$ acre. Ridges 6 feet apart. 2 rows, stands 4 feet apart and staggered.

Harvested from 30th December, 1930 to 5th March, 1931.

Average yield 10 plots sown 16th June, 1930 228·8 lb per acre.

Average decrease 5 plots sown 1st July, 1930 − 40·4 ± 18·1 lb.

Average decrease 4 plots sown 17th July, 1930 − 91·3 ± 20·3 lb.

Root—mean—square—difference between neighbouring control plots = 40·6 lb.

Average percentage of dirty cotton to total yield.

Sown 16th June, 1930 ... ... 14·6%

„ 1st July, 1930 ... ... 20·6%

„ 17th July, 1930 ... ... 17·1%

TABLE No. 12.

Cost of Cultivation of Main Crops, 1930-31
Season in Man-days per acre.

Crop.	Prepara-tion.	Sowing.	After cultivation.	Harvest.	Miscel-laneous.	Total Man-days per acre.
Yams	23·2	23·1	24·2	39·1	—	109·6
Benniseed ...	21·5	3·8	6·1	21·0	—	52·4
Groundnuts ...	29·9	7·2	12·2	98·8	—	148·1 *
Gero	3·8	1·7	9·0	12·2	5·1 (*a*)	31·8
Guinea-corn ...	19·3	4·3	27·4	9·6	—	60·6
Gero and Guinea-corn	14·3	7·6	37·0	18·5	4·9 (*a*)	82·3
Maize	20·2	4·0	2·4	15·0	4·9 (*a*)	46·5
Guinea-corn and Groundnuts	18·9	12·7	21·5	53·5	—	106·6 *
Mucuna	6·9	3·0	8·0	—	—	17·9
Cotton	15·6	3·8	22·0	7·8	—	49·2

(*a*) Watchboys.

(*) Cost of Groundnuts undecorticated.

Cost of labour 6d. per day.

TABLE No. 13a.

COMPARISON OF COST OF PRODUCTION AND REVENUE FROM MAIN CROPS, 1930–31.

Crop.	Cost in Man-days per acre.	Average yield per acre.	Cost of Crop Man-days per lb.	Market Value per lb. (Assumed).	Calculated Return per acre.	Monetary Return per Man-day.	Condition of Crop.
					£ s. d.		
Yam (nett)	109·6	10,520	·014	·125d.	5 9 7	12d.	Tubers.
Benniseed	52·4	277	·189	·696d.	0 16 1	3·68d.	Seed.
Gero	31·8	359	·089	·429d.	0 12 10	4·84d.	Grain.
Guinea-corn	60·6	340·7 367	—	·429d. ·143d.	0 16 $6\frac{1}{2}$	3·27d.	Grain and on head.
Gero and Guinea-corn	82·3	469·5 1,225·5	—	·429d. ·1d. ·143d.	1 9 $5\frac{1}{2}$	4·15d.	Grain and on head.
Maize...	46·5	237 1,609	—	·259d. ·20d.	1 4 7	6·34d.	Grain and dried cobs.

NOTE.—Costs of crops are actual costs. Returns are assumed as follows :—

	£	s.	d.
Combined yield of gero and guinea-corn grain 469·5 lb. at ·429d. per lb. =		16	$9\frac{1}{2}$
Yield of gero on head ... ... 812 lb. at ·1d. per lb. =		6	9
Yield of guinea-corn on head ... 413·5 lb. at 1/7d. per lb. =		5	11
	£1	9	$5\frac{1}{2}$

With guinea-corn grown alone returns are assumed as follows :—

	£	s.	d.
Yield of guinea-corn grain 340·7 lb. at ·429d. per lb. = ...		12	2
Yield of guinea-corn on head 367 lb. at 1/7d. per lb. = ...		4	$4\frac{1}{2}$
	£0	16	$6\frac{1}{2}$

With maize as follows :—

	£	s.	d.
Yield of grain 237 lb. at ·259d. per lb. = ...		5	$1\frac{1}{4}$
Yield of cobs 1,168 lb. at ·20d. per lb. = ...		19	$5\frac{3}{4}$
	£1	4	7

TABLE No. 13b.

COMPARISON OF COST OF PRODUCTION AND REVENUE FROM MAIN CROPS, 1930–31.

Crop.	Cost in Man-days per acre.	Average yield per acre in lb.	Cost of Crop in Man-days per lb.	Market Value per lb. (Assumed).	Calculated Return per acre.	Monetary Return per Man-day.	Condition of Crop.
					£ s. d.		
Groundnuts	239·3*	740	·323	·536d.	1 11 0	1·56d.	Decorticated.
Guinea-corn	62·7*	560	·112	·429d.	1 0 0	3·83d.	Grain.
Gero and Guinea-corn	89·8*	1,038	·086	·429d.	1 17 1	4·95d.	,,
Maize...	97·7*	1,138	·087	·259d.	1 4 7	2·95d.	,,
Cotton	49·2	142	·347	·5d.	0 5 11	1·44d.	Seed Cotton.

* Calculated additional costs to convert all produce into final product.

TABLE No. 14.

Monthly Rainfall—Yandev.

Month.	Average Over 4 Years.	1930.	
	Rainfall Inches.	Rainfall Inches.	No. of days of Rain.
January...	0·54	0·00	0
February	0·15	0·01	1
March	1·38	0·82	2
April	3·62	3·91	7
May	7·67	6·90	12
June	9·02	7·08	13
July	4·46	5·77	11
August	6·24	6·20	18
September	8·68	9·84	21
October	9·35	9·50	19
November	0·70	1·14	4
December	0·44	0·13	1
Total	52·25	51·30	109

ANNUAL REPORT MAIGANA SEED FARM, 1930.

Mr. A. H. S. Vigo—was in charge of the farm throughout the year.

The farm at Maigana has for the last few years been regarded purely as a seed farm for the multiplication of superior strains of cotton, but during the season under review it was developed into a farm centre for the demonstration of mixed farming. A piece of land, eight acres in extent was set aside for this purpose, the necessary sheds were erected for the cattle, and it was farmed on the lines of an ordinary native farm. The results have been most encouraging. Three neighbouring farmers were sufficiently impressed to start this system on their own farms, and were entirely satisfied with it. Several others have intimated their intention of following this example this season and are sending their sons to the farm for instruction in ploughing and the management of cattle. They are also sending their own wood in order that they may have ploughs made by the farm blacksmith. Thus although Maigana will continue to function as a seed farm it is likely that it will more and more become a centre for extension work. A statement of the cost of cultivation under mixed farming together with the yields obtained is given in table No. 5.

Rainfall.

The cropping season of 1930 was not a favourable one for the main crops. The early rains were better distributed than in 1929, but July and August were excessively wet and caused much water logging on the farm. The total rainfall, 52.21 inches was higher than usual but the rains ended very suddenly towards the end of September. The rainfall for October which has a great effect on the cotton crop was only .30 inches, as compared with three inches in 1929 and 3.13 inches in 1928 and both the cotton and guinea corn crops suffered accordingly, the yields of both being smaller than last year.

Cotton—Table No. 2.

A new supply of Strain " D " cotton was supplied by the Botanist for multiplication and 50 acres were sown by the " Balls sand sowing method." Sowing began early in July and germination was good, but the excessive wetness caused the growth of the plants to be very slow and they appeared to make very little progress from the middle of August to the middle of September. The late arrival of the " Harmattan " to some extent offset the absence of rain in October. The yields obtained were the lowest on record. The average yield of seed cotton over the whole 50 acres was only

179 lb. per acre as compared with 286 lb. per acre in 1929 and an average of 339 lb. per acre over the last ten years. This is a matter of considerable interest as owing to the fact that cotton has been grown at Maigana for so many years the yields obtained give a very good indication as to the state of the crop elsewhere in the Province. Block G which is manured at the rate of 1,000 cattle nights every year yielded 326 lb. seed cotton per acre as compared with an average of 487 lb. over the last ten years.

Despite the low yields the crop was picked in good condition and 98.3 *per cent.* of the crop was Grade 1, the ginning percentage being 31 *per cent.*

Jassids were unusually prevalent and " D " strain, proving to be non-resistant, suffered a certain amount of damage. The multiplication of " D " strain has therefore been discontinued for the present, and other strains which are more or less jassid resistent will be tested next season.

Guinea Corn and Millet. *See* Table No. 3.

Ten acres each of guinea corn and millet were grown and the latter was interplanted with mucuna which was allowed to produce seed. After the mucuna seed was harvested cattle were brought on to the land and allowed to graze off the mucuna, subsequently Kraaling the land at the rate of 300 cattle night per acre. The attacks of locusts from June to November did much damage to the guinea corn and millet crops—millet suffered most in this respect—and the yields obtained are therefore the lowest on record.

Green Manuring Crop—Mucuna.

Block " A " (ten acres) was under " Mucuna " for the whole season, and it was subsequently dug in as green manure three weeks before the end of the rains. The amount of green dressing turned in worked out at two and a half tons per acre and the cost of cultivation and digging in was 21 man days per acre.

Seed Crop—Mucuna.

Wet conditions in September greatly hampered the progress of this crop. Only 200 lb. of seed were produced to the acre. The haulms were afterwards fed to cattle.

Miscellaneous Crops.

Small areas of Guinea and Elephant grasses, Tannia and Eddoes, and Sugar Cane were maintained for seed. During the season supplies of both grasses were sent to Samaru in connection with grass experiments conducted there.

TABLE No. 1.

Rainfall Record—Maigana.

Month.	Inches of rain recorded, 1930.	No. of days on which rain fell.	Rainfall, 1929.	No. of days.	Remarks.
January	—	—	—	—	
February	—	—	—	—	
March	—	—	—	—	
April	2·35	4	.19	3	
May	3·13	13	4·85	10	
June	5·04	12	5·41	11	
July	16·65	20	9·58	13	
August	16·33	23	13·15	20	
September	8·41	21	9·19	19	
October	·30	3	3·00	8	
November	—	—	·83	1	
December	—	—	—	—	
	52·21	96	46·20	85	

Increase in 1930 rainfall over 1929 = 6·01.
„ „ „ rain days 1929 = 11.
July and August rendered the farm waterlogged from July to September.

TABLE No. 2.

Yields of Cotton—Strain "D" (Allen.)

Block.	Variety.	Acreage.	Treatment.	Yield per acre in lb. Seed Cotton.	Ginning per cent.	Remarks.
B.	Allen Strain "D"	10 acres	Green Manure—Mucuna, 1929	138·1	31·64	
C.	do.	10 „	Green Manure—Mucuna, 1928	154·6	31·08	Two years cotton.
F.	do.	10 „	do.	115·0	31·15	do.
G.	do.	10 „	1,000 C.N.P.A. Kraaling	326·7	31·22	
H.	do.	10 „	Green Manure—Mucuna, 1928 and 1929	184	29·87	
K.	do.	—	—	—	—	

(1) Cost of cultivation in man-days per acre = 62.
(2) Dates of planting, 3rd to 16th July, 1930.
(3) Dates of harvesting, 3rd January to 3rd February, 1931.
(4) Average yield Seed Cotton per acre, 1929 = 286.
(5) Average yield Seed Cotton per acre, 1930 = 183·68.
(6) Average yield percentage = 31% nearly.

TABLE No. 3.

GUINEA-CORN AND MILLET.

Block.	Plot.	Variety.	Acreage.	Treatment.	Yield per acre. Threshed grain.	Remarks.
E.	—	Millet Bulrush	10 acres	Mucuna folded Land Kraaled at 300 C.N.P.A.	262·3	Selected seed.
E.	—	Kaura ...	5 „	do.	454	do.
E.	—	Farafara...	5 „	do.	412	do.

(1) Cost of cultivation of Millet in man-days per acre = 22.

(2) „ „ „ „ Guinea-corn in man-days per acre = 34.

(3) Date of planting Millet, 13th to 14th April, 1930. Guinea-corn, 16th May, 1930.

(4) Date of harvesting Millet, 5th August, 1930. Guinea-corn, 21st November, 1930.

TABLE No. 4.

Cost of Cultivation of Crops for Season 1930/31 in Man-days per acre.

Crop.	Acreage.	Preparation.	*a.* Kraaling. *b.* Green Manure.	Planting.	Guarding.	Cultivation.	Harvesting.	Ginning.	Total.
Cotton ...	50	16	13 (*a*)	6	—	17	6	4	62
Guinea-corn ...	10	9	2 (*b*)	2·5	·5	16	4	—	34
Millet (Interplanted)	10	6	2	2·5	—	8	4	—	22
Mucuna (Seed Crop)	10	3	—	5	—	16*	9	—	33
Mucuna (Green Manure)	10	—	—	6	—	15†	—	—	21

b. Green Manure every two years. * Includes cost of Threshing Seed. † Includes cost of digging in.

TABLE No. 5.

Crop Costs on Cattle Cultivation.

Plot.	Crop.	Preparation.	Sowing and Supplying.	After Cultivation.	Harvesting.	Total Cost.	Yield of crops per acre in lb. grain.	Remarks.
1–4	Guinea-corn man-days	5·25	4·5	2	6·25	18	1,063	Average for Kaura and Farafara. Crop eaten down by locust during early growing period.
	(4 acres) cattle „	2	—	10	—	12	—	
						30		
5–6	Groundnuts man-days	2	4	3	27·5	36·5	565	934 lb. Hay.
	(2 acres) cattle „	12	—	3	2	17·0	—	
						53·5		
7–8	Cotton man-days ...	12·5	5	5·3	2	24·80	165	Seed Cotton.
	(2 acres) cattle days ...	425	—	5	—	9·75	—	
						34·55		

N.B.—Cattle Day = Two working cattle 7 hours per day and one man.

TABLE No. 1.

Exchange Reactions of Suspensions and Solution in Normal Potassium Chloride.

Eastern Plains.					Ibadan District.				
No.	Place.	Suspension.	Solution.	Diff.	No.	Place.	Suspension.	Solution.	Diff.
48	Ogba ...	4·05	4·05	0·00	143	Olode	7·25	6·70	0·55
57	Benin...	4·90	4·80	0·10	144	„	8·25	6·75	1·50
76	Umudike	3·90	3·95	0·05	145	„	6·95	6·00	0·95
85	Cross River	6·30	6·20	0·10	148	Ikija	7·35	6·20	1·15
94	Umudike	4·45	4·60	0·15					
96	„	4·45	4·45	0·00					
98	„	4·15	4·20	0·05					

TABLE No. 2. 3

Manurial Trial, Ogba Block F.

Treatments.

Plots 3, 6, 9. Control—No Manure.

Plot 2 2½ lb. wood-ashes per tree in June and August.

Plot 4 1 lb. Nitrolim.

Plot 5 2½ lb. rock phosphate.

Plot 6 2½ „ „ „ 1 lb. nitrolim.

Plot 7 2½ „ „ „ 2½ lb. wood-ashes.

Plot 8 2½ „ „ „ 2½ „ „ 1 lb. nitrolim.

Plot.	Treatment.	pH.	Exchange pH 0·2M $CaCl_2$	Exchangeable CaO.	Lime Requirement.	P_2O_5 citric solution.
6	No Manure	4·75	4·15	0·033	0·207	0·0077
4	Nitrolim	6·65	6·10	0·177	0·059	0·0084
5	Phosphate	5·25	4·35	0·182	0·162	0·133
7	Phosphate Ashes ...	5·85	5·15	0·326	0·122	0·136
8	Phosphate Ashes Nitrolim	7·35	6·45	0·284	0·047	0·101

TABLE No. 2.

Composition of Typical Cocoa Soils.

Coarse sand 0·2 m.m.	Fine sand 0·02 m.m.	Silt 0·002 m.m.	Clay 0·0002 m.m.	Loss on Solution.	Moisture air dry soil.	Difference.	Pore Space (p).	Equilibrium Moisture (w).	Total Nitrogen.	Total Carbon.	C/N Ratio.	pH.	Exchange acidity in 0.2M $CaCl_2$	CaO Sol. in HCl.	CaO Exchangeable.	Lime requirement %$CaCO_3$	P_2O_5 Sol. in HCl.
63·1	8·0	1·5	23·5	0·7	1·3	1·9	36·8	24·9	0·066	0·986	14·9	4·45	4·05	0·057	0·037	0·227	0·042
61·6	8·6	1·8	24·3	0·8	1·3	1·6	37·5	26·6	0·068	1·006	14·8	4·70	4·10	0·081	0·045	0·214	0·046
56·2	7·2	1·8	33·0	0·9	1·3	−0·4	43·2	32·5	0·022	...	...	4·80	...	0·069	...	...	0·059
52·3	8·3	2·2	37·0	0·4	1·6	−1·8	42·8	32·3	0·021	0·339	16·1	4·65	...	0·081	...	...	0·055
67·8	6·6	1·5	19·8	0·7	1·2	2·4	41·6	30·1	0·086	...	...	...	...	...	...	...	...
72·8	5·7	2·0	17·3	0·7	0·9	0·6	35·2	22·8	0·065	0·861	13·2	5·35	4·75	0·078	0·68	0·095	0·060
72·8	6·1	2·5	15·3	0·7	1·1	1·5	37·3	24·9	0·089	1·29	14·5	5·10	4·40	0·084	0·80	0·158	0·064
74·4	6·4	1·7	14·8	0·7	1·0	1·0	35·2	23·6	...	...	...	6·15	...	...	...	...	...
71·4	7·3	2·0	16·0	0·7	1·2	1·4	36·2	23·5	...	...	...	...	...	...	...	...	...
59·9	14·0	3·5	19·8	0·9	1·6	0·3	40·2	28·4	0·082	1·30	15·8	4·20	4·05	0·041	0·030	0·310	0·039
53·7	17·5	3·5	22·3	0·9	1·8	0·3	39·5	27·5	0·086	1·44	16·7	4·15	3·95	0·046	0·029	0·321	0·042
43·8	13·8	4·3	35·5	0·9	1·9	−0·9	44·4	33·1	0·055	0·771	14·0	4·70	...	0·060	...	...	0·050
45·7	14·8	3·8	34·0	0·8	1·8	−0·2	42·5	32·0	0·050	...	...	4·75	...	0·043	...	...	0·064
67·0	10·2	2·2	16·8	0·9	1·2	1·7	38·2	26·6	0·083	1·31	15·9	4·55	...	...	...	...	...
38·5	14·9	6·5	32·5	1·3	2·8	3·5	47·2	41·9	0·165	3·05	18·5	4·40	...	...	...	...	...
73·4	11·7	2·5	9·5	0·6	0·8	1·5	32·8	20·5	0·063	1·32	20·9	5·15	4·45	0·068	0·058	0·193	0·074
63·4	10·5	3·3	21·5	0·6	1·2	−0·5	36·3	24·1	0·036	0·485	13·5	5·10	4·30	0·062	...	0·184	0·082
68·2	12·0	3·8	13·0	0·7	1·0	1·3	34·6	22·9	0·064	1·16	18·1	5·00	4·25	0·069	0·049	0·214	0·068
55·1	10·7	2·5	29·8	0·7	1·4	−0·2	39·7	27·6	0·038	0·417	11·0	4·95	4·05	0·064	...	0·216	0·049
80·2	5·0	1·2	11·3	0·7	0·5	1·1	34·4	21·9	0·053	0·719	13·6	5·05	4·30	0·105	0·062	0·184	0·110
...	...	...	...	...	...	...	...	...	0·032	0·405	13·1	5·05	4·05	0·063	...	0·188	0·155
78·7	7·0	2·3	9·5	0·8	0·9	0·8	36·4	23·7	0·053	0·837	15·8	5·10	4·45	0·078	0·057	0·150	0·106
...	...	...	...	...	...	...	...	...	0·031	0·517	16·2	4·70	3·90	0·072	...	0·203	0·163
7·7	50·6	15·2	22·8	2·0	3·1	−1·4	55·5	59·6	0·142	1·55	11·0	5·60	5·80	0·123	0·076	0·131	0·108
1·7	43·9	18·5	29·5	1·8	3·5	1·1	59·0	61·4	0·077	...	...	5·35	...	...	...	...	...
7·5	43·1	17·7	26·8	1·9	3·6	−0·6	58·8	60·3	0·149	1·70	11·4	6·55	6·20	0·472	0·442	0·090	0·123
1·2	44·3	19·4	30·0	1·5	3·3	0·3	57·4	57·0	0·072	...	...	5·55	...	...	...	...	...
25·2	34·4	8·4	28·8	0·7	1·4	1·1	46·0	37·7	0·079	0·774	9·8	6·4	...	0·161	0·145	...	0·078
43·0	27·3	6·5	19·8	1·2	1·3	0·9	44·8	35·0	0·088	0·760	8·7	7·2	...	0·334	0·308	...	0·065
41·4	24·7	9·2	21·8	0·9	1·3	0·1	44·8	34·6	0·040	0·368	9·2	6·7	...	0·158	0·143	...	0·059
41·6	22·8	8·2	24·8	1·1	1·2	0·3	44·5	34·9	0·154	1·44	9·6	7·0	...	0·306	0·299	...	0·160
36·1	16·5	7·0	37·8	0·9	1·3	0·4	45·6	34·1	0·068	0·828	12·2	6·6	...	0·210	0·190	...	0·053
46·1	26·4	9·2	15·0	0·8	1·5	1·0	42·9	32·7	0·092	1·72	18·7	6·9	...	0·479	0·240	...	0·063
43·9	19·9	9·3	25·5	0·8	1·1	−0·5	44·4	33·8	0·045	0·851	15·9	6·2	...	0·278	0·146	...	0·067